H. St. John.

Rhodora

JOURNAL OF THE

NEW ENGLAND BOTANICAL CLUB

Conducted and published for the Club, by

MERRITT LYNDON FERNALD, Editor-in-Chief

JAMES FRANKLIN COLLINS
CHARLES ALFRED WEATHERBY } Associate Editors
LUDLOW GRISCOM

Vol. 36. June, 1934. No. 426.

CONTENTS:

The New England Botanical Club, Inc.

8 and 10 West King St., Lancaster, Pa.

Room 1001, 53 State St., Boston, Mass.

RHODORA.—A monthly journal of botany, devoted primarily to the flora of New England. Price, $2.00 per year, net, postpaid, in funds payable at par in United States currency in Boston; single copies (if available) 20 cents. Volumes 1–8 or some single numbers from them can be supplied only at advanced prices which will be furnished on application. Notes and short scientific papers, relating directly or indirectly to the plants of the northeastern states, will be considered for publication to the extent that the limited space of the journal permits. Forms will be closed five weeks in advance of publication. Authors (of more than two pages of print) will receive 25 copies of the issue in which their contributions appear. Extracted reprints, if ordered in advance, will be furnished at cost.

Address manuscripts and proofs to

M. L. FERNALD, 14 Hawthorn Street, Cambridge, Mass.

Subscriptions (making *all remittances* payable to RHODORA) to
Ludlow Griscom, 8 W. King St., Lancaster, Pa., or Museum of Comparative Zoology, Cambridge, Mass.

Entered at Lancaster, Pa., Post Office as Second Class Mail Matter.

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THE NEW ENGLAND BOTANICAL CLUB

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OEDOGONIUM IN THE VICINITY OF WOODS HOLE, MASSACHUSETTS[1]

CHIN-CHIH JAO

(Plates 286–288)

THE present investigation deals with the genus *Oedogonium* as represented in collections from Woods Hole and its vicinity in Barnstable Country, southeastern Massachusetts, assembled from 1931 to 1933, mostly by Miss Hannah T. Croasdale and the writer, but a few by Professors W. R. Taylor and G. W. Prescott, and Mr. M. W. Bosworth. To date, the writer has noted fifty species, varieties, and forms, of which eleven are new and forty are previously known kinds.

This paper includes detailed descriptions and drawings of the new forms only, but points out some characteristics of the known species which either have not been described completely or exhibit some divergences from the typical forms.

The stations which have yielded fruiting *Oedogonia* to the writer, may be listed as follows:

1. Silver Beach Pond, West Falmouth.
2. Long Pond, East Falmouth.
3. Weeks' Pond (Main Street), Salt Pond, Fresh Pond, and "Chara Pond"[2] (all Shore Road), in and near Falmouth.

[1] Papers from the Department of Botany and Herbarium of the University of Michigan, No. 448 Published with aid to RHODORA from the National Academy of Sciences.

[2] The names in quotation marks pertain to ponds too small or too isolated to have generally known or authentic names. They are either local designations or arbitrary names adopted by workers at the Marine Biological Laboratory. It is expected that a more precise localization and description will accompany a catalog of the fresh-water algae being compiled by Miss H. T. Croasdale.

4. "Harper Pond" (Whitman Road), "Wood Pond" (Ganset Road at Whitman Road), "Endicott Hollow," "Endicott Mire" (Endicott Road), and Iron Pond, in Woods Hole.

5. "Wall Pond," "Stone Wall Pond," "Sheep Pen Pond," "Deer Pond," "Center Pond," and Fawn Pond, on Nonamesset Island, like the following, in the Elizabeth Island chain off Woods Hole.

6. "Dune Pond," on Nashawena Island.

7. "Pasque O," "Pasque K," and "Pasque J," small ponds on Pasque Island.

8. "Sheep Pond," Barmer Pond, "Club House Pond," "Juncus Pond," and "Juncus Pool," on Cuttyhunk Island.

9. A small swamp on Buck Island, between Nonamesset and Naushon Islands.

10. A pond on Naushon Island.

1. OEDOGONIUM ACMANDRIUM Elfving. Wall Pond, Aug. 1, 1933 (*Croasdale*); Aug. 17, 1933 (*Jao*).

2. OEDOGONIUM ACROSPORUM De Bary. Juncus Pond, June 28, and Sept. 1, 1932, Harper Pond, June 26, 1931 and July 3, 1933, and Weeks' Pond, Aug. 10, 1931 (*Croasdale*); Wall Pond, July 5, and Aug. 17, 1933 (*Croasdale & Jao*).

This species was also reported from Grew's Pond, Falmouth, July 20, 1895, by C. P. Nott in Collins, Holden and Setchell, Phycotheca Boreali-Americana No. 163.

3. OEDOGONIUM ACROSPORUM De Bary var. BATHMIDOSPORUM (Nordstedt) Hirn. Wall Pond, Aug. 1, 1933 (*Croasdale*); Aug. 17, 1933 (*Jao*).

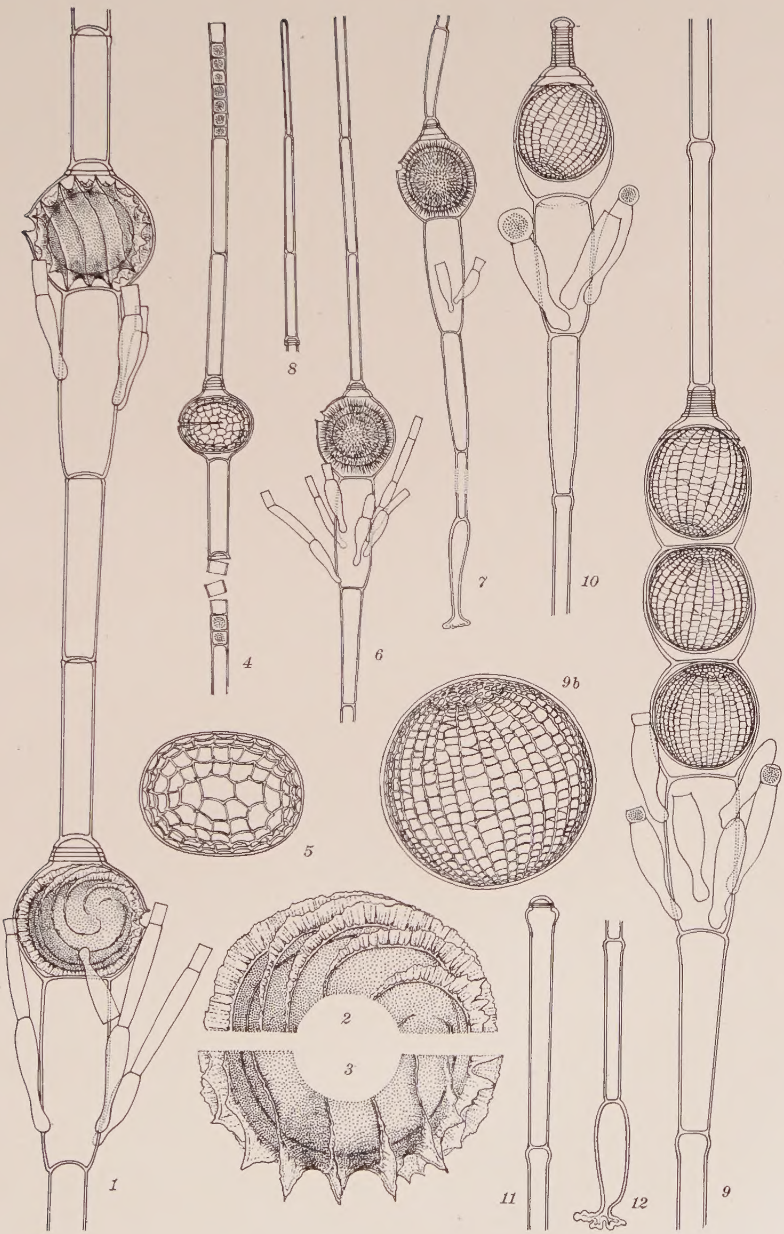
4. OEDOGONIUM ARESCHOUGII Wittrock var. AMERICANUM Tiffany.

Two forms were noted. The first is not exactly like Tiffany's variety, in that the samples show a gynandrosporous habit, lesser dimensions of vegetative cells, and shorter basal cells. Professor Tiffany has suggested to the writer that this variety may be both gynandrosporous and idioandrosporous, and in the other characters also may vary into the range of the Woods Hole material. Full data of the local form are:

Vegetative cells	6.4– 9.6 μ diam.,	23.0–78.4 μ long.
Oogonia	29.0–38.4 μ diam.,	25.6–41.6 μ long.
Oospores	21.0–28.8 μ diam.,	19.2–24.0 μ long.
Androsporangia	8.0– 9.6 μ diam.,	28.8–30.0 μ long.
Antheridia	6.4 μ diam.,	6.4– 8.0 (–9.6) μ long.
Basal cells	9.6–10.0 μ diam.,	28.8–30.0 μ long.

This form was collected in Juncus Pond, Aug. 5, 1933 (*Jao*).

The second form of this plant is idioandrosporous in habit and the dimensions of all portions agree closely with Tiffany's diagnosis, but the vegetative cells are rather shorter, commonly less than 25μ and the greatest length in only a very few cells reaches 61 μ.



OEDOGONIUM SPIRIPENNATUM, figs. 1–3; OE. CYMATOSPORUM var. AREOLIFERUM, figs. 4 and 5; OE. HYSTRICINUM var. EXCENTRIPORUM, figs. 6–8; OE. TAYLORII, figs. 9–12.

This form was collected in a small pond on Pasque Island, July 7, 1933 (*Bosworth*).

5. Oedogonium Areschougii Wittrock var. **contortifilum**, var. nov. (tab. 287, figs. 22–25). Oedogonium dioicum, nannandrium, gynandrosporum; oogoniis 2- vel 7-continuis vel singulis, depresso-globosis, raro subpyriformi-globosis, operculo mediano apertis, circumscissione latere altero lata, altero angusta; oosporis oogoniis conformantibus et lumen complentibus, vel raro partes polares non complentibus, membrana laevi; androsporangiis 1- vel 3(–?)-cellulis plerumque curvatis, subepigynis, raro subhypogynis vel dispersis; nannandribus oboviformibus, unicellulis, in oogoniis sedentibus; cellulis vegetativis capitellatis; saepe ea supra oogonium posita atque cellulis filamenti aliquot aliis curvatis vel spiralibus; cellula basali tumida, breviore quam aliis cellulis vegetativis, raro ad 64 μ longa; cellula terminali apice obtusa.

Cell. veg.	7.5–12 μ diam.,	30–65 μ long.
Oogonia	30.0–33 μ diam.,	26–30 μ long.
Oosporae	26.0–30 μ diam.,	24–26 μ long.
Androsporangia	7.0– 8 μ diam.,	6–12 μ long.
Nannandres	5.0– 7 μ diam.,	9–12 μ long.
Cell. basales	9.6–16 μ diam.,	26–32 μ long.

Dioecious, nannandrous, gynandrosporous; oogonia 1–7, depressed-globose, rarely subpyriform-globose, operculate, division median, one side wide, oospore of same form as the oogonium and filling it, or rarely not filling it longitudinally; spore wall smooth; androsporangia 1–3 (–?), generally curved, subepigynous rarely subhypogynous or scattered; dwarf male obovoid, unicellular, on the oogonium; vegetative cells capitellate, as a rule, the first vegetative cell above the oogonium and some portions of the filament curved or spiral in form; the basal cell enlarged and shorter than the vegetative cell, rarely elongate to 64 μ long; terminal cell apically obtuse.

Weeks' Pond, Aug. 10, 1931, Center Pond. Aug. 12, 1931, Harper Pond, July 3, 1933, and Juncus Pond, Aug. 5, 1933 (*Croasdale*); Harper Pond, Aug. 27, 1933 (*Jao*). Types in the writer's collections and Herb. Univ. Mich., Woods Hole Nos. 43, 87, and 89.

The variety differs from the type and other varieties or forms chiefly by its curved to spiral filaments.

6. Oedogonium autumnale Wittrock. Endicott Mire, Aug. 5, 1933 (*Jao*).

7. Oedogonium boreale Hirn var. **americanum** var. nov. (tab. 287, figs. 16–18). Oedogonium dioicum, nannandrium, idioandrosporum; oogoniis singulis vel 2- vel 4-continuis, frequenter terminalibus vel inter cellulas vegetativas sparsis, depresso-globosis vel late pyriformibus, membrana usque ad 5 μ crassitudine et lamellosa, solum in medio meridionaliter undulato-plicatis, operculo apertis, circum-

scissione lata, supra medium, margine paullulum undulato; oosporis subdepresso-globosis vel globosis, oogonia complentibus vel fere complentibus, membrana laevi; cellulis suffultoriis interdum tumidis, majoribus 25.6 μ; filamentis androsporangiis paullulum gracilioribus quam femineis, androsporangiis singulis vel 2- vel 6-cellulis, interdum tumidis; nannandribus unicellulis, late oboviformibus, in oogonia positis; cellulis vegetativis capitellatis, inferioribus gracilioribus quam superioribus; cellula terminali apice obtusa, saepe substitutione oogonii aut androsporangii nulla; cellula basali tumida, non elongata.

Cell. veg. plant. fem.	12.8–19.2 (–22.4) μ diam.,	32.0–70.4 μ long.
Cell. veg. plant. androsp.	12.8–19.2 μ diam.,	35.2–81.6 μ long.
Oogonia	41.6–54.4 μ diam.,	38.4–54.4 μ long.
Oosporae	33.6–41.6 μ diam.,	32.0–40.0 μ long.
Androsporangia	12.8–16.0 μ diam.,	12.8–19.2 μ long.
Nannandres	8.0–12.8 μ diam.,	9.6–12.8 μ long.
Cellulae basales	19.2–22.4 μ diam.,	32.0–57.6 μ long.

Dioecious, nannandrous, idioandrosporous; oogonia 1–4, scattered or more often terminal, depressed-globose to broadly pyriform, wall up to 5 μ thick and lamellose, with 16–22 longitudinally median folds, operculate, division supramedian and wide, margin slightly undulated; oospore subdepressed-globose, nearly or not filling the oogonium, spore wall smooth; suffultory cell sometimes tumid, reaching a diameter of 25.6 μ; androsporangial plant slightly more slender than the female, androsporangia 1–6, often terminal; dwarf male unicellular, broadly obovoid, situated on the oogonium; vegetative cell capitellate, lower cells generally more slender than the upper; terminal cell apically obtuse, often an oogonium of androsporangium; basal cell enlarged, not elongated.

Pasque J Pond, July 19, 1932 (*Croasdale*). Types in the writer's collections and Herb. Univ. Mich., Woods Hole Nos. 107: 1, 2, and 3.

The species *Oe. boreale* was discovered in Finland by K. E. Hirn, 1900. It is characterized by its large dimensions, thick- and lamellose-walled oogonium. The number of the folds of the oogonium distinguishes it from its nearest relatives, *Oe. megaporum* Wittrock and *Oe. oelandicum* Wittrock & Hirn. In Hirn's description the idioandrosporous habit is given as doubtful, the oogonium is solitary, rarely two, and the folds are from 16 to 19. This new variety is closely related to *Oe. boreale*, but clearly differs from it in having smaller dimensions of all cells, especially the reproductive cells, and the folds as many as 22 in number.

8. Oedogonium Borisianum (Le Clerc) Wittrock. In a swamp on Buck Island, July 24, 1921 (*Taylor* in Herb. Taylor No. 3658); Harper Pond, June 26, 1931, July 3, and July 26, 1933 (*Croasdale*), and Aug. 17, 1933 (*Jao*); Wood Pond, Aug. 29, 1931, and Endicott Hollow, Aug. 5, 1933 (*Croasdale*).

The samples in Professor Taylor's Herbarium are nearly pure and very abundant. Dimensions of the vegetative cells are very variable either on different individuals or on same plant. Generally, the upper cells are broader (to 35.2 μ) and shorter than the lower. In each collection two types of basal cells were noted, namely one form slightly tumid and elongate and the other more enlarged and shortened.

9. Oedogonium Boscii (Le Clerc) Wittrock. In a small pond on Pasque Island, July 7, 1933 (*Bosworth*).

10. Oedogonium Boscii (Le Clerc) Wittrock var. occidentale Hirn. Weeks' Pond, Aug. 10, 1931, and Juncus Pond, Aug. 5, 1933, (*Croasdale*); Wall Pond, Aug. 1, and Aug. 8, 1933 (*Croasdale & Jao*).

11. Oedogonium ciliatum (Hassall) Pringsheim. In the writer's samples, the oogonia were usually solitary, rarely two together, division of the operculum was generally nearly supreme, the androsporangia were usually two, and the vegetative cell was small (8–16.4 μ diam., 48–86.4 μ long). This plant was always very short, the whole filament usually less than ten cells in length.

Wall Pond, June 10, and July 5, 1933 (*Croasdale*); Aug. 17, 1933 (*Jao*).

12. Oedogonium concatenatum (Hassall) Wittrock. The local plants have ellipsoid, subobovoid-globose, or globose oospores, with the longitudinally arranged pits in about 40–62 series, the suffultory cell and its adjunct vegetative cells curved. The antheridia show alternate unequal development of opposite sides, giving the antheridial series a wavy form. They form two sperms by horizontal division. The dimensions of all cells are a little smaller than those of the typical plant, except that the vegetative cells are shorter and slightly broader. Otherwise this material was like the type. Full data of the local form are listed:

Vegetative cells	25.6–44.8 μ diam.,	64.0–160.0 μ long.
Oogonia	64.0–76.8 μ diam.,	70.4–112.0 μ long.
Oospores	57.6–73.6 μ diam.,	64.0– 83.2 μ long.
Suffultory cells	51.2–60.8 μ diam.,	115.2–134.4 μ long.
Androsporangia	27.2–32.0 μ diam.,	12.8– 32.0 μ long.
Male stipes	16.0–22.4 μ diam.,	52.8– 64.0 μ long.
Antheridia	9.6–12.8 μ diam.,	11.2– 22.4 μ long.

Endicott Mire, Aug. 5, 1933 (*Croasdale*).

13. Oedogonium crassiusculum Wittrock var. idioandrosporum Nordstedt & Wittrock. Club House Pond, June 28, 1932 (*Croasdale*); Barmer Pond, June 27, 1933 (*Jao*). The specimens collected in Barmer Pond have smaller dimensions of all cells and the oogonium very rarely is angular-globose in form. Full data of the form are:

Vegetative cells	19.0–30 μ diam.,	60–103 μ long.
Oogonia	42.0–54 μ diam.,	45– 60 μ long.
Oospores	38.0–52 μ diam.,	41– 52 μ long.
Androsporangia	20.0–26 μ diam.,	10– 26 μ long.

Male stipes	9.5–15 μ diam.,	52– 62 μ long.
Antheridia	7.0–9 μ diam.,	10– 16 μ long.

14. Oedogonium crenulatocostatum Wittrock forma cylindricum Hirn. Harper Pond, July 3, 1933 (*Croasdale*) and Aug. 17, 1933 (*Jao*).

15. Oedogonium crenulatocostatum Wittrock var. longiarticulatum Hansgirg. Harper Pond, Aug. 17, 1933 (*Jao*).

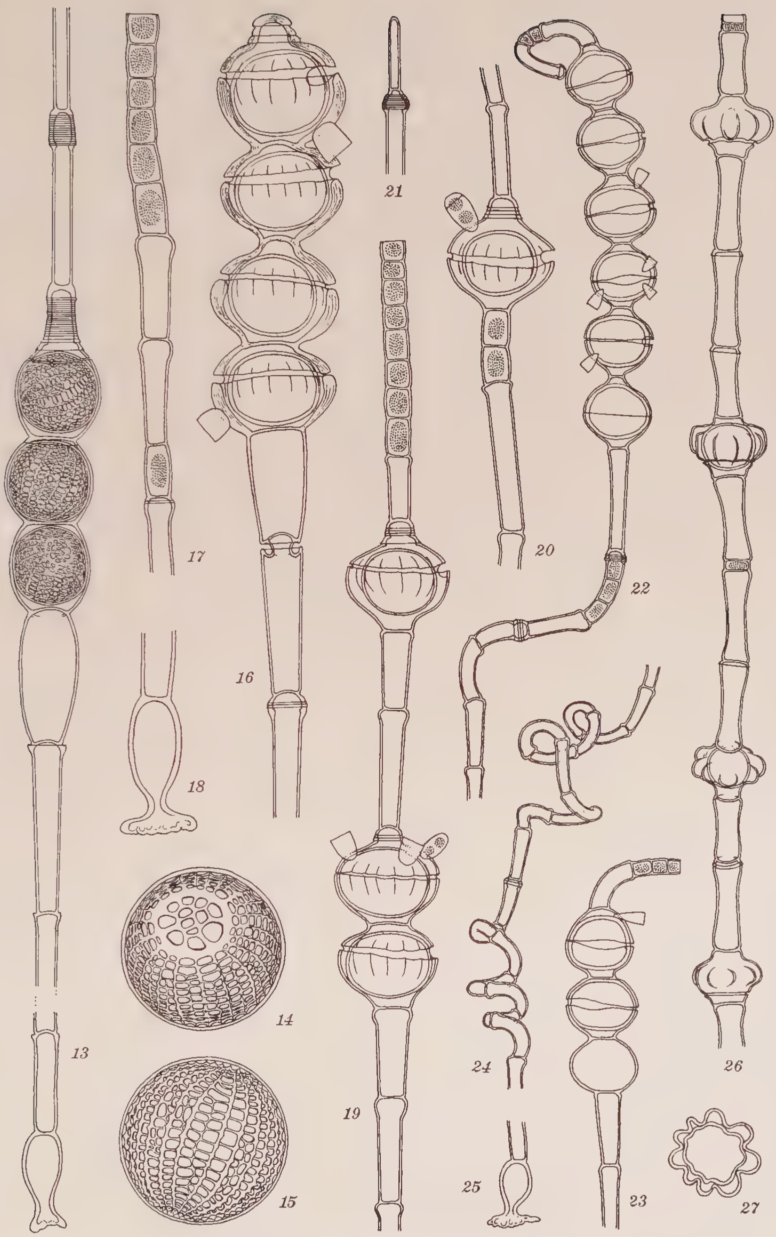
16. Oedogonium crispum (Hassall) Wittrock var. gracilescens Wittrock. Sheep Pen Pond, June 11, 1932, Pasque O Pond, June 7, 1932, Iron Pond, June 26, 1933, Wall Pond, July 5, 1933 (*Croasdale*); Pasque K Pond and another small pond on the same island, June 7, 1933 (*Bosworth*).

17. Oedogonium crispum (Hassall) Wittrock var. uruguyayense Magnus & Wille. Weeks' Pond, June 28, 1932 (*Croasdale*).

18. **Oedogonium Croasdaleae**, sp. nov. (tab. 288, figs. 31–35). Oedogonium dioicum, nannandrium, gynandrosporum; oogoniis singulis vel bis vel septies continuis, plerumque in parte filamenti superiore positis, quadrangulari-ellipsoideis vel subobovi formibus vel subellipsoideis, operculo apertis, circumscissione superiore, interdum lata; oosporis oogoniis conformantibus et lumen plane vel raro subtus vix complentibus, membrana triplici, episporio extus laevi, mesosporio crasso et lamelloso longitudinaliter costato (in sectione optica transversaliter undulato), costis anastomosantibus, irregulariter undulato, in medio oosporae circa 16–30; endosporio granulato; cellulis suffultoriis tumidis; androsporangiis saepe 8-seriatis, epigynis, raro hypogynis vel subhypogynis; nannandribus cyathiformibus, curvatis, in cellulis suffultoriis vel raro in oogoniis sedentibus, retinaculo irregulariter lobato; antheridiis singulis, interioribus; inferioribus cellulis vegetativis gracilioribus quam superioribus; cellula terminali obtusa saepe a oogonio aut a androsporangio supposita; cellula basali interdum paullulum tumida, retinaculo lobato praedita. Oogonium interdum deest, saepe ab androsporangiis suppositum, sed in filamentis iis absentia oogonii abnormalibus sunt cellulae suffultoriae atque nannandres semper normaliter positi.

Cell. veg.	20–30 μ diam.,	95.0–230.0 μ long.
Oogonia	56–77 μ diam.,	80.0–116.0 μ long.
Oosporae	54–73 μ diam.,	77.0–105.0 μ long.
Cell. suffultoriae	39–72 μ diam.,	70.0–147.0 μ long.
Androsporangia	10–55 μ diam.,	6.4– 76.8 μ long.
Nannandres	10–15 μ diam.,	55.0– 63.0 μ long.

Dioecious, nannandrous, gynandrosporous; oogonia 1–7, generally on the upper portion of the filament, quadrangular-ellipsoid, subobovoid, or subellipsoid, operculate, division superior, sometimes wide; oospore of the same form as the oogonium and filling it, rarely not reaching the lower end, spore membrane of three layers: outer layer smooth, median layer thick and lamellose, with 16–30 anastomosing, irregularly undulate, longitudinal ribs, inner layer granulate;



Oedogonium reticulocostatum, figs. 13–15; Oe. boreale var. americanum, figs. 16–18; Oe. oelandicum var. Novae-Angliae, figs. 19–21; Oe. Areschougii var. contortifilum, figs. 22–25; Oe. platygynum var. ambiceps, figs. 26 and 27.

suffultory cell tumid; androsporangia to 8-seriate, epigynous, rarely hypogynous or subhypogynous; dwarf male goblet-shaped, curved, on the suffultory cell, occasionally on the oogonium, holdfast irregularly lobed, antheridium 1, interior; filaments tapering toward the base; terminal cell obtuse, often an oogonium or androsporangium; basal cell sometimes a little swollen, with a lobed holdfast. Oogonium occasionally absent or poorly developed, often replaced by androsporangia, but the suffultory cell and dwarf males in their usual positions.

This is the only known species which is characterized by a granulate inner spore wall, and also the only nannandrous member of the genus possessing a gynandrosporous habit, superior operculum, longitudinally ribbed oospores, and interior antheridia. It bears some resemblance to *Oe. michiganense* Tiffany. It differs, however, in having larger dimensions, the vegetative cells not being capitellate, in having quadrangular-ellipsoid, subobovoid, or subellipsoid oogonia and oospores, with a larger number of ribs, and granulate inner spore-wall. It also looks like members of the "cyathigerum" and "Wolleanum" group. It is distinguished clearly by its operculate character and granulate inner spore-wall.

Harper Pond, June 26 and Aug. 10, 1931, and July 3, 1933 (*Croasdale*) and Aug. 27, 1933 (*Jao*); Wood Pond, Aug. 10 and 29, 1931, Wall Pond July 7, 1932, and Pasque J Pond, July 19, 1932 (*Croasdale*). TYPES in the writer's collections and Herb. Univ. Mich., Woods Hole Nos. 40–45 and 87.

19. OEDOGONIUM CRYPTOPORUM Wittrock. Salt Pond, Aug. 11, 1931 (*Croasdale*); Chara Pond, July 23, 1933 (*Jao*); Pasque K Pond, July 7, 1933 (*Bosworth*); a pond on Naushon Island, July 17, 1917 (*Taylor*, in Herb. Taylor, No. 2565).

20. OEDOGONIUM CRYPTOPORUM var. VULGARE Wittrock. Stone Wall Pond, June 11, 1932, Iron Pond, June 26, 1933, Harper Pond, July 3, 1933, and Juncus Pond, Aug. 5, 1933 (*Croasdale*); Wall Pond, Aug. 17, 1933 (*Jao*); a pond on Naushon Island, July 17, 1917 (*Taylor* in Herb. Taylor, No. 2565).

The dimensions of the Wall Pond specimens are rather larger than those of the plants which were collected from other localities.

21. OEDOGONIUM CYMATOSPORUM Hirn var. **areoliferum**, var. nov. (TAB. 286, FIGS. 4, 5). Oedogonium monoicum; oogoniis singulis, depresso-globosis, poro mediano rimiformi apertis; oosporis forma oogoniis similibus et ea complentibus, membrana triplici; episporio et endosporio laevi, mesosporio areolato (in sectione optica undulato); antheridiis 4- vel 7-cellularibus, subepigynis, subhypogynis vel dispersis; spermatozoidiis singulis; cellula terminali obtusa.

Cell. veg.	6.4– 9.6 μ diam.,	25.6–64.0 μ long.
Oogonia	28.8–32.0 μ diam.,	25.6–41.0 μ long.
Oosporae	25.6–28.8 μ diam.,	19.2–25.6 μ long.
Antheridia	6.4– 9.6 μ diam.,	6.4– 9.6 (–12.8) μ long.

Monoecious; oogonium solitary, depressed globose, pore median, rimiform; oospore similar in form to the oogonium and filling it, the spore wall of three layers: the outer and inner smooth, the middle areolate; antheridia 4–7, subepigynous, subhypogynous or scattered; sperm single; terminal cell obtuse.

This variety shows some characteristics of *Oe. cymatosporum* Wittrock & Nordstedt, but is distinguished chiefly by its areolate median spore wall, constantly depressed-globose oogonia and oospores, and smaller dimensions of the fruiting cells. The illustration given by Hirn shows a foveolate rather than an areolate spore wall, and Tiffany's figure conforms. In the familiar species of this genus which are characterized by monoecious habit and a median rimiform pore, no areolate spore types have previously been found. The only monoecious representatives of the genus with reticulate oospores are *Oe. dictyosporum* Wittrock and its forma *Westii* Tiffany. This new variety is distinguished from these in having the pore median, fruiting cells depressed, an areolate median spore-wall, and lesser dimensions.

Wall Pond, June 10, and July 5, 1933 (*Croasdale*); Aug. 17, 1933 (*Jao*). Types in the writer's collections and Herb. Univ. Mich., Woods Hole Nos. 67, 68, 90, and 91.

22. Oedogonium echinospermum Braun. Wall Pond, Aug. 1, 1933, (*Croasdale*); Aug. 17, 1933 (*Jao*).

23. Oedogonium elegans West & West var. **americanum**, var. nov. (tab. 288, figs. 28–30). Oedogonium dioicum, nannandrium, gynandrosporum vel (?) idioandrosporum; oogoniis singulis operculo apertis, circumscissione medianis; oosporis depresso-globosis, oogonia complentibus; membrana laevi; androsporangiis 1–2, subhypogynis vel sparsis, paullulum tumidis; spermatozoidiis singulis; cellulis vegetativis, androsporangiis, et oogoniis dense et minute granulatis, granulis spiraliter dispositis; cellulis vegetativis expanse capitellatis; cellula terminali apice obtusa; cellula basali subhemisphaerica vel depresso-globosa; membrana verticaliter plicata.

Cell. veg.	4.8– 8.0 μ diam.,	25.6–67.8 μ long.
Oogonia	27.2–32.0 μ diam.,	24.0–27.2 μ long.
Oosporae	20.8–28.8 μ diam.,	19.2 μ long.
Androsporangia	8.0– 9.6 μ diam.,	9.6–12.8 μ long.
Cell. basalis	14.4–17.0 μ diam.,	11.5–13.0 μ long.

Dioecious, nannandrous, gynandrosporous or idioandrosporous (?); oogonium solitary, depressed-globose, operculate, division median; oospore depressed-globose, filling the oogonium or not, spore-wall

smooth; androsporangia 1–2, subhypogynous or scattered, generally a little tumid; vegetative cells, oogonis, and androsporangia densely and minutely granulate, the granules spirally arranged; vegetative cells broadly capitellate; terminal cell apically obtuse; basal cell subhemispherical to depressed-globose; wall vertically plicate.

The species *Oe. elegans* is found only in Ceylon as reported by West. In the description and drawings only the vegetative cells are marked by minute granules and the capitellate character of the vegetative cells was not pointed out, though suggested by the slight lateral swelling of a few cells in his figures. This variety is clearly characterized by its broadly capitellate vegetative cells and the granulate oogonia, androsporangia, and vegetative cells.

Salt Pond, Aug. 11, 1931 (*Croasdale*). TYPES in the writer's collections and Herb. Univ. Mich., Woods Hole Nos. 108: 1 — 5.

24. OEDOGONIUM GLOBOSUM Nordstedt. Salt Pond, Aug. 11, 1931, (*Croasdale*).

25. OEDOGONIUM GRANDE Kuetzing & Wittrock. This is one of the most common Oedogonia occurring in the region. Fresh Pond, Sept. 1, 1929, (in Herb. Taylor No. 15037); Stone Wall Pond, June 11, 1932, Harper Pond, June 26, and July 29, 1931 and July 26, 1933, Club House Pond, June 11, 1932, Wall Pond, July 7, 1932, and Endicott Hollow, Aug. 26, 1933, (*Croasdale*); Sheep Pond, June 27, and Harper Pond, Aug. 17, 1933, (*Jao*). This species was also reported from Long Pond, Falmouth, July 1895, by C. P. Cott, in Collins, Holden and Setchell: Phycotheca Boreali-Ameridana No. 519.

26. OEDOGONIUM GRANDE Kuetzing & Wittrock var. ANGUSTUM Hirn. Harper Pond, July 3, 1933, Stone Wall Pond, July 7, 1933, and Endicott Hollow, Aug. 5, 1933 (*Croasdale*); Harper Pond, Aug. 17, 1933, (*Jao*).

27. OEDOGONIUM HYSTRICINUM Transeau & Tiffany var. **excentriporum**, var. nov. (TAB. 286, FIGS. 6–8). Oedogonium dioicum, nannandrium, (?) idioandrosporum; oogonio solitario, oboviformi-globoso, poro supra medium aperto; oosporis subglobosis vel globosis, oogonia complentibus, raro vix complentibus, membrana triplici: mesosporio et endosporio laevi, episporio dense echinato; cellulis suffultoriis tumidis; nannandribus paullulum curvatis, in cellulis suffultoriis sedentibus, stipite interdum bi- vel tricellulari; cellula basali interdum subtumida non elongata; cellula terminali obtusa.

Cell. veg.	6.0– 8.0 μ diam.,	40.0–94 μ long.
Oogonia	22.0–35.0 μ diam.,	38.0–48 μ long.
Oosporae (C. echin.)	27.0–32.0 μ diam.,	32.0–35 μ long.
Cell. suffultoriae	12.0–19.5 μ diam.,	47.0–54 μ long.
Nannadrium stipes		
Cell. inferior	5.0– 6.5 μ diam.,	10.0–21 μ long.
Cell. superior	3.5– 6.5 μ diam.,	9.5–26 μ long.
Cell antherid	5.0– 6.0 μ diam.,	5.0–12 μ long.

Dioecious, nannandrous, (idioandrosporous ?); oogonium solitary, obovoid-globose, pore supramedian, oospore subglobose to globose, filling the oogonoium, rarely nearly filling it, spore-wall of three layers: median and inner layers smooth, outer layer densely echinate; suffultory cell swollen; dwarf male slightly curved, on the suffultory cell, stipe 1- to 3-celled; antheridium 1, exterior; basal cell sometimes a little tumid, not elongate; terminal cell obtuse.

This variety distinctly belongs to *Oe. hystricinum* Transeau & Tiffany in having the densely echinate oospore and swollen suffultory cell, but is clearly differentiated from the type, by the smaller dimensions of its vegetative cells, pore not median, male stipes 1- to 3-celled, and basal cell not elongated.

Harper Pond, June 3, 1933 (*Croasdale*) and Aug. 17, 1933, (*Jao*). Types in the writer's collections and Herb. Univ. Mich., Woods Hole Nos. 43 and 47.

28. Oedogonium intermedium Wittrock. Wood Pond, Aug. 10, 1931 and Salt Pond, Aug. 11, 1931 (*Croasdale*).

29. Oedogonium inversum Wittrock. Deer Pond, July 7, 1932 (*Croasdale*); Chara Pond, June 23, 1933 (*Jao*); a pond on Naushon Island, July 17, 1917 (*Taylor* in Herb. Taylor No. 2565).

30. Oedogonium macrandium Wittrock var. propinquum (Wittrock) Hirn. Long Pond, June 14, 1933 (*Croasdale*).

31. Oedogonium mammiferum Wittrock & Nordstedt. Sheep Pen Pond, July 5, 1931, Deer Pond, July 7, and Sept. 11, 1932, and Wall Pond, June 5, 1933 (*Croasdale*); Chara Pond, June 23, 1933 and Sheep Pond, June 27, 1933 (*Jao*).

32. Oedogonium minus Wittrock. The dimensions are a little smaller than those of the typical forms. The oospore sometimes fills the oogonium, and the vegetative cells are distinctly capitellate. The full data are:

Vegetative cells	4.8–12.8 μ diam.,	25.6–84.0 μ long.
Oogonia	32.2–44.8 μ diam.,	35.2–41.6 μ long.
Oospores	28.8–38.4 μ diam.,	22.4–35.2 μ long.
Antheridia	12.0–13.0 μ diam.,	3.2– 9.6 μ long.

Wall Pond, Aug. 17, 1933 (*Jao*).

33. Oedogonium mitratum Hirn. Chara Pond, June 22, 1933 (*Jao*).

34. Oedogonium nobile Wittrock var. minus Hirn. The dimensions of this local form are not exactly like the typical plants with respect to the reproductive cells. The antheridia range up to 6-seriate. The full data are:

Vegetative cells	12.8–22.4 μ diam.,	114.0–173.0 μ long.
Oogonia	57.6–60.8 μ diam.,	96.0– 80.0 μ long.
Oospores	54.4–57.6 μ diam.,	70.4– 73.6 μ long.
Antheridia	16.0–17.6 μ diam.,	6.4– 12.8 μ long.

Endicott Mire, Aug. 5, 1933 (*Croasdale*).

35. Oedogonium oelandicum Wittrock & Hirn var. **Novae-Angliae**, var. nov. (tab. 287, figs. 19–21). Oedogonium dioicum, nannandrium, gynandrosporum; oogoniis 2- vel 4-continuis vel singulis, depresso-globosis, in medio plicatis, plicis ?–16 aequatorialibus verticillatis, nondum regionem polarem attingentibus, operculo supra medium circumcisso, margine undulata; oosporis oogoniis conformantibus et lumen plane complentibus, raro (praecipue longitudinaliter) non complentibus, membrana laevi; cellulis suffultoriis saepe tumidis; androsporangiis 2- vel 7-cellularibus vel unicellularibus, subepigynis, hypogynis, vel sparsis; nannandribus oboviformibus, unicellularibus, in oogoniis sedentibus; spermatozoidiis binis, divisione horizontali natis; cellulis vegetativis capitellatis; cellula basali tumida; cellula terminali apice obtusa, interdum quam cellulis vegetativis tenuiore.

Cell. veg.	9.6–16 μ diam.,	32.5–86.0 μ long.
Oogonia	40.0–51 μ diam.,	33.0–43.2 μ long.
Oosporae	35.0–43 μ diam.,	30.0–36.0 μ long.
Cell. suffult.	13.0–20 μ diam.,	30.0–64.0 μ long.
Androsporangia	11.0–14 μ diam.,	9.0–17.0 μ long.
Nannandres	8.0–10 μ diam.,	9.5–13.0 μ long.

Dioecious, nannandrous, gynandrosporous; oogonia 1 — 4, depressed-globose, with ?–16 longitudinal median plicae, operculate, division supramedian, margin undulate; oospore of the same form as the oogonium and filling it, rarely a little shorter and not filling it completely, spore-wall smooth; suffultory cell sometimes tumid; androsporangia 1–7 (–?), subepigynous, hypogynous, or scattered; dwarf male obovoid, unicellular, seated on the oogonium; sperms 2, division horizontal; vegetative cells capitellate; basal cell enlarged; terminal cell apically obtuse, sometimes more slender than the vegetative cells.

This variety is characterized by its large dimensions, especially of the fruiting cells, which serve to distinguish it from the type form of the species and from f. *minus* Børge. It also bears some resemblance to *Oe. megaporum* Wittrock, *Oe. costatum* Transeau, and *Oe. boreale* Hirn. It differs, however, from the first by its larger oogonia and oospores, from the second by the lesser dimensions of its female fruiting cells, the oogonium 1- to 4-seriate, and in that the verticillate folds of the oogonium do not reach to poles, and from the third in having lesser dimensions, and the oogonial wall not thick and lamellose.

Harper Pond, July 3, 1933, and Endicott Mire, Aug. 5, 1933 (*Croasdale*), and by *Jao* at the first station, Aug. 27, 1933. Types in the writer's collections and Herb. Univ. Mich., Woods Hole Nos. 40–50 and 87.

36. Oedogonium platygynum Wittrock. Silver Beach Pond, Sept. 1, 1933 (*Croasdale*).

37. Oedogonium platygynum Wittrock var. **ambiceps**, var. nov. (tab. 287, figs. 26, 27). Oedogonium dioicum, nannandrium, gynandrosporum; oogoniis singulis, depresso-globosis, in medio plicis 8–10 verticillatis, elongatis, obtuse rotundatis instructis, operculo apertis, circumscissione infra medium, margine undulata vel recta; oosporis subglobosis vel globosis, interdum depresse lateque costatis, costis brevibus verticillatis; oosporis oogoniis conformantibus, oogonia omnino vel raro vix complentibus (plicationibus oogonii exceptis); membrana laevi; androsporangiis 1–vel 2-cellularibus, subepigynis vel subhypogynis; cellula vegetativa distincte utrinque capitellata.

Cell. veg.	9.6–12.8 μ diam.,	22.4–41.6 μ long.
Oogonia	32.0–38.4 μ diam.,	22.4–28.8 μ long.
Oosporae	19.2–25.6 μ diam.,	19.2–22.4 μ long.
Androsporangia	11.2–12.8 μ diam.,	3.2 μ long.

Dioecious, nannandrous, gynandrosporous; oogonium solitary, depressed-globose, with 8–10 long rounded projections arranged in a whorl about the middle, operculate, the division inframedian, margin undulate or straight; oospore subglobose to globose, sometimes with low projections like those of the oogonium, quite or rarely nearly filling the oogonium exclusive of the projections, spore-wall smooth; androsporangia 1–2, subepigynous or subhypogynous; vegetative cells distinctly capitellate at bothends.

This variety is characterized chiefly by the large dimensions of its oogonia and oospores and in that its vegetative cells are capitellate at both ends, in these points differing from the type and the other form and variety.

Juncus Pond, Aug. 5, and Wall Pond, June 5, 1933 (*Croasdale*); Wall Pond, Aug. 17, 1933 (*Jao*). Types in the writer's collections and Herb. Univ, Mich., Woods Hole Nos. 89–91.

38. Oedogonium pratense Transeau. Pasque K Pond, June 7, 1933 (*Bosworth*); Wall Pond, July 5, 1933 (*Croasdale*).

39. Oedogonium pusillum Kirchner. Sheep Pen Pond, July 5, 1933 (*Croasdale*).

40. Oedogonium pungens Hirn. Weeks' Pond, Aug. 10, 1933 (*Croasdale*).

41. Oedogonium Reinschii Roy. Sheep Pond, June 27, 1933 (*Jao*).

42. **Oedogonium reticulocostatum**, sp. nov. (tab. 287, figs. 13–15). Oedogonium dioicum; oogoniis 2- vel 8-continuis vel singulis, globosis, vel subglobosis, vel suboboviformi-globosis, superne circumscissis, operculo minimo, interdum latiusculo; oosporis globosis, maturitate aurantiacis, oogonia complentibus, interdum longitudinaliter non complentibus, membrana triplici; episporio et endosporio laevi, mesosporio longitudinaliter costato (in sectione optica undulato), costis denticulatis et incrassatis, in medio oosporae 10–22, inter se transverse costulatis, interdum anastomosantibus reticula-

tionem distinctam formantibus, pro parte marginem disci polaris non attingentibus, regione polari reticulata disciformi, axe transverso vel obliquo; cellulis suffultoriis tumidis; cellulis vegetativis paullum capitellatis, cum acutis angulis superioribus; cellula terminali obtusa vel anguste conica; cellula basali tumida. Planta mascula ignota.

Cell. veg.	8.0–16.0 μ diam.,	44.8–86.4 μ long.
Oogonia	(25.8–) 28.8–36.7 μ diam.,	32.0–46.0 (–72) μ long.
Oosporae	(23–) 27.2–32.0 μ diam.,	27.2–32.0 μ long.
Cell. suffult.	22.4–25.6 μ diam.,	44.8–57.6 μ long.

Dioecious; oogonia 1–8, globose, subglobose, or subobovoid-globose, operculate, division supreme, narrow; oospore globose, orange at maturity, filling the oogonium, except sometimes the length, spore-wall of three layers, the outer and inner smooth, the median layer with 10–22 longitudinal, toothed and thickened ribs, connected by transverse, sometimes anastomosing lines to from coarse reticulations; polar region reticulate, disc-shaped; polar axis transverse or oblique to the axis of filament; ribs in part not reaching the margin of the polar disk; suffultory cell swollen; vegetative cells slightly capitellate the upper angles acute; the terminal cell apically obtuse to sharply conical; the basal cell enlarged. Male plant unknown.

This species is characterized by the supreme position of the operculum, and by the longitudinally toothed ribs which join directly to the margins of the discoid polar areas and are connected by transverse lines to form a reticulum, which serves to distinguish these plants from the group of *O. monile*, to which this species is probably most nearly related.

Collected in a small pond on Pasque Island, July 7, 1933 (*Bosworth*). TYPE in the writer's collections and Herb. Univ. Mich., Woods Hole No. 64.

43. OEDOGONIUM RUGULOSUM Nordstedt. Details additional to the description in Tiffany's monograph are: this species is gynandrosporous, androsporangium usually solitary, hypogynous, a little swollen, 6 — 7.5 μ diam., and 10 — 11 μ long, terminal cell apically obtuse, or replaced by an oogonium; the basal cell slightly enlarged; commonly epiphytic on other species of Oedogonium or other algae.

Iron Pond, June 26, 1933, Wall Pond, July 19, 1932, and Endicott Mire and Juncus Pond, Aug. 5, 1933 (*Croasdale*); Harper Pond, July 3 and 26, 1933 (*Croasdale and Jao*).

The specimens collected in Harper Pond were slightly larger than those collected from other stations.

44. OEDOGONIUM SANCTI-THOMAE Wittrock & Cleve (?). Harper Pond, Aug. 17, 1933 (*Jao*).

45. OEDOGONIUM SEXANGULARE Cleve. Salt Pond, Aug. 11, 1931, Weeks' Pond, Aug. 10, 1931, and Harper Pond, June 26, and July 29, 1931 and June 3 and July 26, 1933 (*Croasdale*); Harper Pond, Aug. 17, 1933 (*Jao*).

46. Oedogonium sexangulare Cleve var. majus Wille. Harper Pond, June 26 and Aug. 29, 1931, June 3 and July 26, 1933 and Iron Pond, June 26, 1933 (*Croasdale*); Harper Pond, Aug. 17, 1933 (*Jao*).

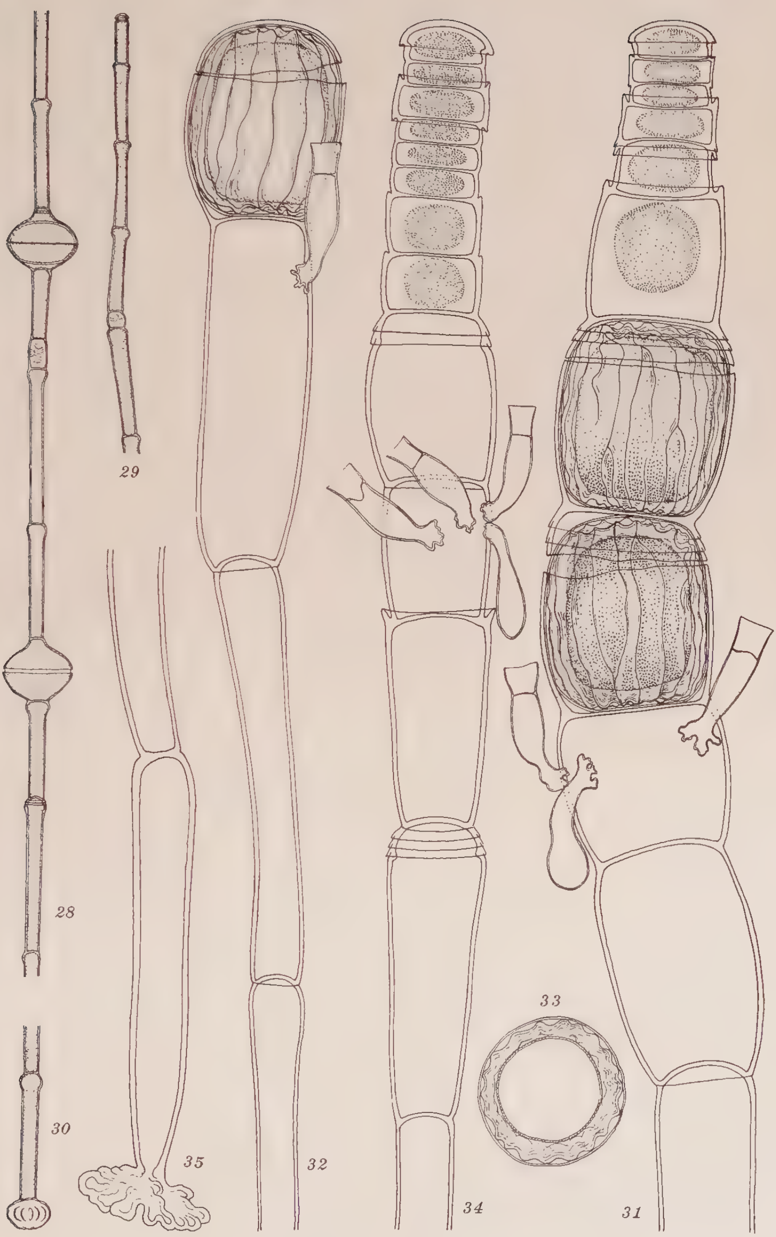
47. **Oedogonium spiripennatum**, sp. nov. (tab. 286, figs. 1–3). Oedogonium dioicum, nannandrium, (?) idioandrosporum; oogoniis singulis, subglobosis vel oboviformi-globosis, poro mediano apertis; oosporis globosis vel subglobosis, oogonia complentibus, membrana triplici: episporio subtiliter granulato-costato, costis, 5–7 spiralibus dentatis membranaceo-alatis, ad polos inter se anastomosantibus; axe semper transversali; cellulis suffultoriis tumidis; nannandribus paullulum curvatis, in cellulis suffultoriis sedentibus, stipite 1- vel 2-cellulari; antheridio exteriore, unicellulari; spermatozoidiis singulis; cellulis vegetativis inferioribus gracilioribus quam superioribus; cellula basali paullulum tumida, retinaculo lobato; cellula terminali obtusa.

Cell. veg.	16.0–22.4 μ diam.,	44.8–89.6 μ long.
Oogonia	48.0–57.6 μ diam.,	48.0–61.0 μ long.
Oosporae	44.8–54.4 μ diam.,	41.6–51.2 μ long.
Cell. suffult.	25.6–32.0 μ diam.,	64.0–80.0 μ long.
Nannand. stipes		
Cell. superior	6.4– 8.0 μ diam.,	38.4–48.0 μ long.
Cell. inferior	9.6–12.8 μ diam.,	35.2–44.8 μ long.
Antheridia	6.4– 9.0 μ diam.,	5.0–16.0 μ long.
Cell. basalis	19.2 μ diam.,	60.8 μ long.

Dioecious, nannandrous, idioandrosporous (?); oogonium solitary, subglobose to obovoid-globose, pore median, oospore globose or subglobose, filling the oogonium, spore-wall of three layers: the median and inner smooth, the outer layer finely granulate, with 5 — 7 spiral, toothed, membranous-winged ribs uniting at the poles; the polar axis always placed in a transverse position, never parallel with the filament; the suffultory cell swollen; the dwarf male a little curved, on the suffultory cell, rarely on the oogonium or near by the suffultory cell; stipe cells 1 — 2; antheridium 1, exterior; sperm 1; lower vegetative cells of the filament generally more slender than the upper, but the basal cell slightly enlarged, with a lobed holdfast; terminal cell apically obtuse.

This species is near *Oe. illinoisense* Transeau and *Oe. spiralidens* Jao. It differs, however, from the first in having membranous-winged ribs on a granulate outer spore-wall, the male stipe cells 1 — 2, antheridium 1, vegetative cells larger, and reproductive cells rather smaller, especially the cells of the dwarf male plants, and from the second, in having membranous-winged ribs, male stipe 1- to 2-celled, antheridium 1, and in its larger dimensions.

Wall Pond, June 10 and July 5, 1933 (*Croasdale*); Aug. 17, 1933 (*Jao*). Types in the writer's collections and Herb. Univ. Mich., Woods Hole Nos. 67, 68, 90, and 91.



Oedogonium elegans var. americanum, figs. 28–30; Oe. Croasdaleae, figs. 31–35.

48. Oedogonium suecicum Wittrock. Dune Pond (south), June 24, 1931, Iron Pond, June 26, 1933 (*Croasdale*); Wall Pond, Aug. 17, 1933 (*Jao*). The specimens from Iron Pond are a little smaller than the typical form.

49. Oedogonium tapeinosporum Wittrock. Wall Pond, Aug. 17, 1933 (*Jao*).

50. **Oedogonium Taylorii**, sp. nov. (tab. 286, figs. 9–12). Oedogonium dioicum, nannandrium, idioandrosporum; oogoniis singulis vel 2- vel 3-continuis, globosis vel ellipsoidali-globosis, poro superiore apertis; oosporis globosis, raro subellipsoidali-globosis, oogonia complentibus vel partes polares non complentibus, membrana triplici: episporio etiamque endosporio laevi, mesosporio longitudinaliter costato (in sectione optica transversaliter undulato), costis crenulatis vel dentatis, in medio oosporae 22–28, inter se costulis distinctis transversalibus, interdum anastomosantibus conjunctis, costis paucis ad polos non attingentibus, regione polari disciformi et reticulata, axe cum eo filamenti directione fere continente; cellulis suffultoriis tumidis; androsporangiis 1- vel 4-seriatis, terminalibus; nannandribus in cellulis suffultoriis sedentibus, stipite paullulum curvato, antheridiis exterioribus, unicellulis, globosis, prope apicem operculo dehiscentibus; spermatozoidiis singulis; cellulis vegetativis latiusculis capitellatis; cellula terminali obtusa, in filamentis femineis frequenter substitutione oogonii nulla; cellula basali tumida, retinaculo irregulariter lobato substrato affixa.

Cell. veg.	8.0–19.2 μ diam.,	38.4–112.0 μ long.
Oogonia	35.2–51.2 μ diam.,	46.4– 73.6 μ long.
Oosporae	32.0–46.2 μ diam.,	32.0– 51.2 μ long.
Cell. suffult.	32.0–33.6 μ diam.,	54.4– 73.6 μ long.
Androsp.	16.0–17.6 μ diam.,	16.0– 22.8 μ long.
Stip. nannandr.	9.6–12.8 μ diam.,	48.0– 51.2 μ long.
Antheridia	6.4(–16) μ diam.,	4.8– 6.4 μ long.
Cell. basalis	12.8–19.2 μ diam.,	48.0– 89.6 μ long.

Dioecious, nannandrous, idioandrosporous; oogonia 1–3, globose or ellipsoid-globose, with superior pore; oospore globose, very rarely subellipsoid-globose, partly or completely filling the oogonium, spore-wall of three layers: the outer and inner smooth, the middle with 22–28 crenulate to slightly dentate, longitudinally continuous ribs, connected by transverse, sometimes anastomosing lines, some ribs not continued to the polar regions; polar regions disc-shaped and reticulate in structure, polar axis nearly parallel to the filament; suffultory cell enlarged; androsporangia 1–4 (–?), mostly terminal on the filament; dwarf male a little curved, on the suffultory cell; antheridium 1, exterior, globose, dehiscing by an operculum near the apex; sperm single; vegetative cell capitellate, not very broad; terminal cell obtuse, on the female plant sometimes becoming an oogonium; basal cell enlarged, with an irregularly lobed attachment.

In this genus only *Oe. michiganense* Tiffany is characterized by

possessing a capitellate vegetative cell, a subapical operculum, and longitudinally ribbed oospores. The new species is distinguished from this, however, in having an idioandrosporous habit, peculiar features of spore-wall and dwarf male, and smaller dimensions of all cells.

Fawn Pond, June 18, and July 14, 1933 (*Croasdale*); Aug. 17, 1933 (*Jao*). Types in the writer's collections and Herb. Univ. Mich., Woods Hole Nos. 95–97.

51. Oedogonium undulatum (Brebisson) Al. Braun forma senegalense (Nordstedt) Hirn (subforma). This Oedogonium was found in a pool near West Chop, Martha's Vineyard, Massachusetts by *W. J. V. Osterhout* in 1883. In Hirn's "Monographie der Oedogoniaceen" (p. 261, Tab. XLV, Fig. 277) this type is described as a subform of f. *senegalense*. It differs from the latter in having the vegetative cell with four deep constrictions, the three median swellings secondarily constricted and the terminal two entire, and oogonia 1- to 5-seriate, The Woods Hole specimens are exactly like Hirn's description and figure, except that the oogonia are 1- to 2-seriate and the dwarf males are shorter (26–33 μ long).

Sheep Pen Pond, July 5, 1933 and Salt Pond, Aug. 11, 1931 (*Croasdale*); Pasque K Pond, June 7, 1933 (*Bosworth*).

This investigation was initiated at the Marine Biological Laboratory, Woods Hole and carried to completion in the Department of Botany, University of Michigan, Ann Arbor, Michigan, under the direction of Professor Wm. R. Taylor, to whom the writer is deeply grateful for his advice; the writer wishes also to thank the collectors for material, especially Miss H. T. Croasdale, and Professor L. H. Tiffany for his valuable suggestions as to the new forms.

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EXPLANATION OF PLATES

Plate 286

Figs. 1–3. Oedogonium spiripennatum Jao, sp. nov. Fig. 1, part of the filament, with two oogonia containing oospores in lateral view (upper)

and polar view (lower), and the dwarf males on the suffultory cells (× 315); FIG. 2, part of oospore, showing the granulate outer spore-wall with the toothed and membranous-winged ribs in polar view (× 630); FIG. 3, same as FIG. 2, in lateral view (× 630).

FIGS. 4, 5. OEDOGONIUM CYMATOSPORUM Hirn var. AREOLIFERUM Jao, var. nov. FIG. 4, part of the filament, with one oogonium and two series of antheridia in the subhypogynous and scattered positions (× 315); FIG. 5, an oospore, showing the areolate median spore-wall (× 630).

FIGS. 6–8. OEDOGONIUM HYSTRICINUM Transeau & Tiffany var. EXCENTRIPORUM Jao, var. nov. FIG. 6, part of the filament, with one oogonium and six dwarf males on the swollen suffultory cell, two of these have the stipes 2- or 3-celled (× 315); FIG. 7, part of the filament, showing one oogonium, two dwarf males, and a slightly tumid basal cell (× 315); FIG. 8, an upper part of the filament, showing the obtuse terminal cell (× 315).

FIGS. 9–12. OEDOGONIUM TAYLORII Jao, sp. nov. FIG. 9, part of the filament, with three oogonia and six dwarf males, two of which are immature (× 315); FIG. 9b, an oospore, showing the characteristics of the median spore-wall (× 630); FIG. 10, upper part of the filament, showing the terminal oogonium and three dwarf males (× 315); FIG. 11, terminal cell (× 315); FIG. 12, basal cell (× 315).

PLATE 387

FIGS. 13–15. OEDOGONIUM RETICULOCOSTATUM Jao, sp. nov. FIG. 13, part of the filament, showing three oogonia either in lateral view (upper two) or polar view (lower one), and the swollen basal cell (× 315); FIG. 14, oospore in polar view (× 630); FIG. 15, oospore in lateral view (× 630).

FIGS. 16–18. OEDOGONIUM BOREALE Hirn var. AMERICANUM Jao, var. nov. (× 315). FIG. 16, upper part of the filament, showing a series of terminal oogonia, two broad unicellular dwarf males on the oogonia, and a vegetative cell in a division stage below the suffultory cell; FIG. 17, part of the filament, with two series of androsporangia; FIG. 18, basal cell.

FIGS. 19–21. OEDOGONIUM OELANDICUM Wittrock var. NOVAE-ANGLIAE Jao. var. nov. (× 315). FIG. 19, part of the filament showing two series of oogonia, the subepigynous androsporangia, and the dwarf males, one of which contains two sperms; FIG. 20, part of the filament, with an oogonium, a mature dwarf male, and two hypogynous androsporangia; FIG. 21, terminal cell.

FIGS. 22–25. OEDOGONIUM ARESCHOUGII Wittrock var. CONTORTIFILUM Jao, var. nov. (× 315). FIG. 22. Part of the filament, with six oogonia, two series of androsporangia, and five dwarf males on the oogonia, showing the curved cells; FIG. 23, part of the filament, showing the curved portion above the oogonia. This form is very commonly found with fruiting filaments; FIG. 24, part of the filament, showing the spiral characteristic; FIG. 25, basal cell.

FIGS. 26, 27. OEDOGONIUM PLATYGYNUM Wittrock var. AMBICEPS Jao, var. nov. (× 360). FIG. 26, part of the filament, showing four solitary oogonia and two subepigynous and one subhypogynous androsporangia; FIG. 27, oospore in polar view, showing the projections on both the oogonium and oospore.

PLATE 288

FIGS. 28–30. OEDOGONIUM ELEGANS West & West var. AMERICANUM Jao, var. nov. (× 315). FIG. 28, part of the filament, with two solitary oogonia and a subhypogynous androsporangium; FIG. 29, upper part of the filament showing the terminal cell and an isolated androsporangium; FIG. 30, basal part of the filament, showing the depressed-globose and vertically plicate basal cell.

Figs. 31–35. Oedogonium Croasdaleae Jao, sp. nov. (× 315). Fig. 31, upper part of the filament, with two oogonia, six epigynous androsporangia, and three dwarf males, one of which is immature; fig. 32, upper part of the filament, showing the terminal oogonium; fig. 33, median part of the oospore seen in polar view, showing the thickened, lamellose, and undulate median wall between smooth outer and finely granulate inner walls; fig. 34, upper part of the filament, showing a poorly developed oogonium and the suffultory cell, dwarf males, and androsporangia in their usual condition.

SOME FEATURES OF THE FLORA OF THE OZARK REGION IN MISSOURI[1]

Julian A. Steyermark

To the student of phytogeography the area comprised in the state of Missouri offers a field of exceptional interest mainly on account of the great diversity of its physiographic features, which are the result of its long geological history as a land area. Within the limits of the state are found the low-lying swamp region of the southeast, the comparatively smooth or slightly rolling prairie mostly north of the Missouri River, and south of that great watercourse the vast semi-mountainous, heavily forested Ozark Plateau. The geology of the region is equally diverse. The area to the north of the Missouri River is covered by a nearly continuous sheet of glacially transported soils, clays and gravels, mostly of Kansan drift material, whereas to the south of this stream lies an ancient unglaciated region, the Ozark Plateau, consisting of sedimentary rocks of Paleozoic age with an ancient igneous core of Pre-cambrian origin, the entire Ozark region being one of the oldest land areas on this continent. The Ozark area, together with the Boston Mountains of northern Arkansas and eastern Oklahoma and the Ouachita Mountains of western Arkansas and central Oklahoma, become conspicuous, consequently, as the only prominent series of elevations lying between the Appalachians and the Rocky Mountains to the east and west, and between the Great Lakes and the Gulf of Mexico to the north and south.

It is thus apparent that Missouri should possess a flora of exceedingly diverse elements. It is a cosmopolitan area, botanically speaking, both as a result of this diversity and also because it lies within a definite transition zone where several distinct floristic provinces meet. The Prairie and Great Plains floras enter the region from the west and north; the Coastal Plain and swamp floras from the south and

[1] Published with aid to Rhodora from the National Academy of Sciences.

southeast penetrate the southeast corner of the state; the semi-arid flora of the southwest protrudes slightly into the southern portion; some of the ancient southern Appalachian upland floras appear in various places in the Ozark Plateau; and finally, some of the elements of the Canadian flora from the north and northeast descends into the state, intermixed with the more common Alleghanian element, constituting a truly heterogeneous assemblage of floras of widely diverse origins in time and place.

A general survey of the flora within this area reveals the still more striking and interesting fact that a considerable portion of the flora is a restricted one from the standpoint of distribution within the state. Of course, many of the species have a more or less general range in Missouri; nevertheless, for a large number of them the area of dispersal is restricted. Such limited distribution is often associated directly with a definite type of habitat. Some of the more important explanations that may account for the restriction in habitat and distribution of a species living under its present environmental conditions are that (1) the habitat was selected because the species found in it the optimum conditions for survival—perhaps a definite relationship between soil and water, chemical or physical nature of the substratum, evaporation-exposure ratio, percentage of relative light and shade, etc.; (2) present climatic and physiographic zones—affected by prevailing winds, distribution of rainfall and temperature, relief features, proximity to the sea, altitude, types of substrata, and many other factors; resulting in turn from the past geological history of the land—may have influenced or even forced the species to adapt itself to the conditions and to establish itself there; (3) past geological history may have determined its present known range by the effects of glaciation, diastrophism and orogeny, flooding by continental seas, etc.—that is, a restricted species may be living in territory geologically youthful or may be a relic or endemic because it has been confined within an area geologically more ancient which escaped glaciation or which was not encroached upon by continental seas, or was not influenced, as were surrounding areas, by various forces of diastrophism, orogeny, etc., or it may be an ancient endemic because it survived in a nunatak region; or it may be localized because it is too old to move and has lost its aggressiveness, a fact often shown in many of Dr. Fernald's studies, particularly in his treatise[1] "The

[1] Fernald, M. L. Persistence of plants in unglaciated areas of Boreal America. Mem. Am. Acad. 15: 239–342. 1925.

Persistence of Plants in Unglaciated Areas" etc. In the case of a given species one or all of these explanations may be needed to account for the present habitat and distribution. In many cases, the geological history may have served as the basic reason for isolating the species in certain areas; in other cases, the geological history may have been the primary cause in isolating the species in a general region, but subsequent causes, such as changes in climatic and physiographic zones, or soil relationships, etc., may have been the secondary and, perhaps, final issue in further limiting the habitat and distribution. There are so many phases to this subject that but a few can be briefly discussed in the present paper.

In connection with the flora of the Ozark region it would appear that geological history has fundamentally determined the broader relationships of the floristic elements, but that other factors have secondarily modified and confined to narrower limits the present native flora. One of the seemingly most important reasons in accounting for certain types of distribution of species found in the Ozark region as well as elsewhere is the chemical nature of the substratum and its associated phenomena. Where other conditions in the environment remain relatively constant in a given region, the soil factor often becomes the deciding one, particularly in regions of residual soils. Dr. Wherry has often brought out the strong correlation existing between the distribution of a species and the chemical nature of the substratum in his numerous studies on soil acidity. Dr. Fernald has often emphasized the chemical nature of the soil as important in the study of plant distribution, and in the case of certain North American species of alpine and subalpine plants has correlated their present distribution with lithological factors.[1] Again, in the area of residual rocks in the Mineral Springs region of Adams County, Ohio, Dr. E. L. Braun[2] found a very striking correlation between the distribution of the various species and the underlying rock component. The summary of this work is as follows: "The most striking correlation between vegetation and any environmental feature of the Mineral Springs region, is the relation of plant communities to underlying rock. The physical and chemical properties of the soils—the available water, the colloidal content, the H-ion,

[1] Fernald, M. L. The soil preferences of certain alpine and subalpine plants. Rhodora **9**: 149–193. 1907.

[2] Braun, E. L. Vegetation of the Mineral Springs region, Adams county, Ohio. Ohio Biol. Surv. Bull. **15**: 513. 1928.

and perhaps, indirectly, the nitrogen content—are affected by or are derivatives of the original rock materials. The primary classification of the vegetation on a geological basis is an acceptance of the importance of this influence which remains apparent throughout all successions." The famous soil chemist, Hilgard,[1] defined a calcareous soil as one which supported a calcicolous vegetation, and one of his chief claims was that the type of soil becomes an important and frequently a decisive factor in determining the distribution of a particular species. Field geologists often recognize the importance of the vegetational covering, and are able frequently to locate definite substrata and horizons by noting certain plant species.

The unglaciated Ozark region in Missouri is one of residual soils arranged in belts of varying width which conform to each geological formation represented. Briefly stated, the southeast portion of the state contains the Archaean rocks which are the oldest in the Mississippi Basin; these rocks are chiefly granites, rhyolites, and porphyritic trachytes. These igneous rocks are found nowhere else in Missouri except for an isolated occurrence in Camden County. Around this ancient igneous core, which forms the nucleus for later formations, occur successively younger and younger sedimentary strata, comprising limestones, dolomites, shales, sandstones, and cherts. These younger rocks surround the igneous core in ring-like belts of varying width and irregularity. The youngest rocks exposed around the margin of the Ozark belt are those of Pennsylvanian age, whereas the oldest, lying immediately about the igneous core, date back to Cambrian. This concentric character of the distribution of Paleozoic formations surrounding the igneous mass is much better developed on the east than on the west slope of the crystalline area. A subordinate center around which the rings are deflected lies in Camden and Laclede counties. Rocks of Cambrian and Ordivician age occupy most of the area of the Ozark Dome in Missouri. Due to this concentric arrangement of the formations the distances by which similar types of rock are separated from each other may be quite marked. Sandstones of one age may be isolated from those of another by intervening outcrops of other types of rocks. For example, a straight line drawn in the southeastern Ozark region in Missouri, from Perryville, Perry Co., southwest to Eminence, in Shannon Co., reveals the occurrence of limestones, dolomites, chert, sandstone,

[1] Hilgard, E. W. Soils: their formation, properties, composition, and relations to plant growth in the humid and arid regions. p. 593. New York. 1907.

and porphyritic trachyte, which, because of their general concentric arrangement in relation to the igneous core, appear in restricted belts.

As found in many other areas of residual soil, rocks of diverse chemical composition result in chemically dissimilar soils, and these, in turn support divergent types of plant associations. However, the occurrence of various species on a definite substratum is well marked in Missouri only when the plant is closely associated with the substratum, i. e., when the residual soil is thin and thus retains the marked chemical properties of the substratum. Conversely, a residual soil which, as a result of much disintegration by weathering and sufficient accumulation of organic matter, has reached a certain depth where it ceases to be little or not at all influenced by the chemical nature of the rock substratum, usually supports species of a more general range whose occurrence is not necessarily limited to the underlying substratum. Soils of this type, often occurring in the deeper deposits of woods, fields, meadows, etc., are frequently circumneutral, and may result from rocks of very dissimilar chemical properties. In such types of soils the factor of acidity or alkalinity in limiting the vegetation is mostly eliminated, or, at least, decidedly counteracted by other factors associated therewith. On these mostly circumneutral types of soils occur many of the common Missouri plants of fields, meadows, and woods. Such woodland species as *Erigenia bulbosa, Dentaria laciniata, Dicentra Cucullaria, Anemone virginiana, Sanicula canadensis, Uvularia grandiflora*, etc., are in this class, and they frequent circumneutral soils which are sufficiently deep, rich, moist, and shaded, regardless of whether the area is one of limestone, sandstone, chert, or granite. Such species, as well as many others of similar habitat, have a more or less general range over the state, probably because the conditions under which they develop are themselves widespread. It is in connection, however, with the species in Missouri which in their distribution within the state occur locally, irregularly, or in conformation to a particular kind of substratum that the soil factor assumes importance. As stated elsewhere, rocks of either basic or acidic properties may give rise to circumneutral soils. Alkaline soils in Missouri result from limestone areas, whereas the acid soils are derived from sandstone, chert, granite, or porphyritic trachyte. Depending upon the degree of leaching which has occurred, both acidic and basic types of soils may result from dolomite or magnesian limestone areas. The acidic condition is produced by

extensive leaching, whereby most, if not all, of the calcium carbonate is washed out, leaving the magnesium element in excess. When there is no pronounced amount of leaching the resulting substratum is mostly alkaline. In Missouri, but in the Ozark region in particular, two main types of distribution of species in relation to certain soils are found. One large group comprises the oxylophytes, or, in other words, those confined to or favoring areas of acidic rocks. The other group includes the calciphiles, or those which occur in areas of limestone or other calcareous rocks, and which seem to favor or be restricted to such rocks.

The oxylophytes make up a large proportion of the flora of the sandstone, chert, granite, and porphyritic trachyte areas, especially of the barrens formed by the weathering of these rocks. A list of some typical oxylophytes in Missouri comprises the following:—

Polypodium virginianum L.
Pteridium latiusculum (Desv.) Hier. var. pseudocaudatum (Clute) Maxon
Cheilanthes lanosa (Michx.) Watt
Asplenium pinnatifidum Nutt.
Asplenium Trichomanes L.
Asplenium Bradleyi D. C. Eaton
Thelypteris palustris (Salisb.) Schott var. pubescens (Lawson) Fernald
Thelypteris marginalis (L.) Nieuwl.
Thelypteris spinulosa (O. F. Müll.) Nieuwl. var. intermedia (Muhl.) Nieuwl.
Dennstaedtia punctilobula (Michx.) Moore
Osmunda regalis L. var. spectabilis (Willd.) Gray
Osmunda cinnamomea L.
Lycopodium lucidulum Michx.
Lycopodium complanatum L. var. flabelliforme Fernald
Selaginella rupestris (L.) Spring
Isoëtes melanopoda J. Gay
Pinus echinata Mill.
Erianthus divaricatus (L.) Hitchc.
Andropogon Elliottii Chapm.
Andropogon saccharoides Sw.
Andropogon ternarius Michx.
Sorghastrum nutans (L.) Nash
Digitaria villosa (Walt.) Pers.
Paspalum stramineum Nash
Panicum depauperatum Muhl.
Panicum perlongum Nash
Panicum linearifolium Scribn.
Panicum dichotomum L.
Panicum sphaerocarpon Ell.
Panicum Scribnerianum Nash
Panicum scoparium Lam.
Aristida dichotoma Michx.
Aristida basiramea Engelm.
Aristida ramosissima Engelm.
Aristida longespica Poir.
Aristida intermedia Scribn. & Ball
Aristida lanosa Muhl.
Aristida oligantha Michx.
Aristida purpurascens Poir.
Muhlenbergia tenuiflora (Willd.) BSP.
Muhlenbergia capillaris (Lam.) Trin.
Sporobolus Drummondii (Trin.) Vasey
Agrostis Elliottiana Schultes
Danthonia spicata (L.) Beauv.
Festuca octoflora Walt.
Gymnopogon ambiguus (Michx.) BSP.
Tricuspis elongatus (Buckl.) Nash
Cyperus inflexus Muhl.
Cyperus retrofractus (L.) Torr.
Cyperus filiculmis Vahl var. macilentus Fern.
Fimbristylis Vahlii (Lam.) Link
Scirpus carinatus Gray
Hemicarpha micrantha (Vahl) Pax
Rynchospora capitellata (Michx.) Vahl
Scleria pauciflora Muhl.
Scleria ciliata Michx.
Carex hirsutella Mack.
Carex varia Muhl.
Juncus polycephalus Michx.
Juncus aristulatus Michx.

Luzula campestris (L.) DC.
  var. bulbosa A. Wood
Smilax glauca Walt.
Hypoxis hirsuta (L.) Coville
Habenaria peramoena Gray
Spiranthes gracilis (Bigel.) Beck
Goodyera pubescens (Willd.) R. Br.
Carya alba (L.) K. Koch
Carya ovalis Sarg.
  var. obovalis Sarg.
Carya Buckleyi Dur.
  var. arkansana Sarg.
Quercus marilandica Muench.
Quercus coccinea Muench.
Quercus stellata Wang.
Quercus velutina Lam.
Alnus rugosa (Du Roi) Spreng.
Rumex hastatulus Baldw.
Rumex Acetosella L.
Polygonum tenue Michx.
Polygonum sagittatum L.
Polygonella americana (Fisch. & Mey.) Small
Froelichia floridana (Nutt.) Moq.
Froelichia gracilis Moq.
Anychia polygonoides Raf.
Geocarpon minimum Mack.
Cerastium arvense L.
  var. oblongifolium (Torr.) Hollick & Britton
Cerastium viscosum L.
Talinum parviflorum Nutt.
Talinum calycinum Engelm.
Portulaca retusa Engelm.
Portulaca pilosa L.
Ranunculus Harveyi (Gray) Britton
Selenia aurea Nutt.
Sedum Nuttallianum Raf.
Sullivantia renifolia Rosendahl
Saxifraga pennsylvanica L.
  var. Forbesii (Vasey) Engl. & Irmsch.
Saxifraga virginiensis Michx.
Desmodium rotundifolium (Michx.) DC.
Desmodium sessilifolium (Torr.) T. & G.
Desmodium rigidum (Ell.) DC.
Desmodium obtusum (Muhl.) DC.
Lespedeza procumbens Michx.
Lespedeza repens (L.) Pers.
Lespedeza striata (Thunb.) H. & A.
Lespedeza hirta (L.) Hornem.
Clitoria mariana L.
Galactia volubilis (L.) Britton
Rynchosia latifolia Nutt.
Polygala verticillata L.
Linum sulcatum Riddell
Linum striatum Walt.
Crotonopsis elliptica Willd.
Acalypha gracilens Gray
  var. monococca Engelm.
Tragia cordata Michx.
Ilex verticillata (L.) Gray
  var. padifolia (Willd.) T. & G.
Ilex opaca Ait.
Vitis rotundifolia Michx.
Ascyrum hypericoides L.
Hypericum petiolatum Walt.
Hypericum gentianoides (L.) BSP.
Hypericum Drummondii (Grev. & Hook.) T. & G.
Helianthemum Bicknellii Fern.
Lechea villosa Ell.
Lechea tenuifolia Michx.
Viola pedata L.
Viola sagittata Ait.
Viola pallens (Banks) Brainerd
Rhexia mariana L.
Rhexia interior Pennell
Oenothera linifolia Nutt.
Chaerophyllum Tainturieri Hook.
  var. floridanum Coult. & Rose
Spermolepis echinata (Nutt.) Heller
Cynosciadium pinnatum DC.
Daucus pusillus Michx.
Nyssa sylvatica Marsh.
Nyssa aquatica L.
Monotropa uniflora L.
Monotropa Hypopitys L.
Rhododendron roseum (Loisel.) Rehder
Vaccinium arboreum Marsh.
  var. glaucescens (Greene) Sarg.
Vaccinium stamineum L.
Vaccinium virgatum Ait.
  var. tenellum (Ait.) Gray
Vaccinium vacillans Kalm
  var. crinitum Fern.
Steironema quadriflorum (Sims) Hitchc.
Polypremum procumbens L.
Frasera caroliniensis Walt.
Apocynum androsaemifolium L.
Phlox bifida L.
Isanthus brachiatus (L.) BSP.
Trichostema dichotomum L.
Hedeoma hispida Pursh
Pycnanthemum incanum (L.) Michx.
Pycnanthemum albescens T. & G.
Cunila origanoides (L.) Britton
Linaria vulgaris Hill
Linaria canadensis (L.) Dumont
  var. texana (Scheele) Pennell
Chelone glabra L.
Aureolaria grandiflora (Benth.) Pennell
  var. serrata (Torr.) Pennell

Aureolaria flava (L.) Farw.
var. macrantha Pennell
Aureolaria calycosa (Mack. & Bush) Pennell
Aureolaria pectinata (Nutt.) Pennell
var. ozarkensis Pennell
Agalinis heterophylla (Nutt.) Small
Agalinis purpurea (L.) Pennell
Agalinis viridis (Small) Pennell
Plantago aristata Michx.
Plantago virginica L.
Plantago elongata Pursh
Galium arkansanum Gray
Galium pilosum Ait.
Diodia teres Walt.
Mitchella repens L.
Houstonia caerulea L.
Houstonia patens Ell.
Houstonia minima Beck
Houstonia ciliolata Torr.
Valerianella longiflora (T. & G.) Walp.
Liatris squarrosa Willd.
Chrysopsis camporum Rydb.
Solidago petiolaris Ait.
var. Wardii (Britton) Fern.
Solidago caesia L.
Solidago hispida Muhl.
Solidago nemoralis Ait.
Solidago radula Nutt.
Solidago leptocephala T. & G.
Aster patens Ait.
Aster anomalus Engelm.
Aster pilosus Willd.
var. demotus Blake
Aster linariifolius L.
Erigeron pulchellus Michx.
Erigeron divaricatus Michx.
Antennaria plantaginifolia (L.) Richards.
Antennaria fallax Greene
Gnaphalium purpureum L.
Gnaphalium obtusifolium L.
Gnaphalium obtusifolium L.
var. micradenium Weatherby
Ambrosia bidentata Michx.
Coreopsis pubescens Ell.
Helenium tenuifolium Nutt.
Artemisia caudata Michx.
Senecio plattensis Nutt.
Krigia Dandelion (L.) Nutt.
Krigia virginica (L.) Willd.
Hieracium scabrum Michx.
Hieracium Gronovii L.

There is a considerable amount of difference in the degree of toleration of various plants to acidity, and some of the species listed as oxylophiles above may in other places be found extending their range into areas of circumneutral soils.

More rarely are the oxylophytes in this flora confined to one type of rock or to a particular geological formation. So far as is known, *Lycopodium lucidulum* and var. *porophilum*, *Saxifraga pennsylvanica* var. *Forbesii*, *Thelypteris palustris* var. *pubescens*, and others occur only in sandstone regions. Even more unusual are those oxylophytes confined to but one geological formation. For example, *Viola pallens*, *Goodyera pubescens*, *Dennstaedtia punctilobula*, and *Lycopodium complanatum* var. *flabelliforme* have been found only on the La Motte sandstone, a formation which occurs chiefly in a few counties around the crystalline area in southeast Missouri. *Saxifraga pennsylvanica* var. *Forbesii* and *Sullivantia renifolia* are known only from the St. Peter sandstone area, which circumscribes a narrow but continuous belt along the eastern and northeastern border of the Ozark Dome. The various sandstone areas, particularly the St. Peter and La Motte formations, seem to harbor a more peculiar and restricted flora, species of great rarity or localized occurrence in Missouri, than either the chert or igneous areas. The Roubidoux

sandstone, which is the most widely distributed sandstone formation in the Ozark region, occupies a large area in the central Ozark region and persists as the surface rock over some large areas. It is the prevailing surface rock over the extensive sandstone plateau of Dent and adjacent counties. It is the formation which underlies much of the pine forest area in many of the southeastern Ozark counties. Being so widely distributed as a surface or near-surface formation in the Ozark region, it is the chief factor in extending the range of many oxylophytes over a larger area. It is very significant that many calciphiles which in Missouri are found only on limestone or dolomite areas are absent from this area underlain by Roubidoux sandstone. *Grindelia lanceolata* is a typical calciphile, and in Missouri is confined to the Ozark region, but is known only from limestone or dolomite glades or rocky prairies. Abundant on the limestone areas that cap the surface in southwestern Missouri, particularly on the Joachim and Jefferson City limestones, it occurs locally elsewhere in the Ozark region only on limestone north to Camden Co. and east to Jefferson Co. In between, in the portion of the central Ozark Plateau underlain by Roubidoux sandstone, it is entirely absent. *Grindelia lanceolata* is a good example of this sort of interrupted distribution because of intervening sandstone areas occupying the surface formation, and a considerable number of other species in the Ozark region show a similar restriction.

Similarly, the areas of calcareous rock in the Ozark region support a definite and restricted flora. The best examples of this calcicolous type of vegetation are found on the limestone glades and bald knobs. These edaphic areas maintain a characteristic xerophytic flora, some of the species of which are found on the limestone glades of the southern Alleghanies and adjacent plateau regions, limestone areas in Arkansas and eastern Oklahoma, and on portions of the Edwards Plateau and adjacent plateau sections of Texas. A number of species exhibit this type of distribution, as, for example, *Grindelia lanceolata* and *Ophioglossum Engelmanni*. Many of the species occurring on the limestone and dolomite barrens in Missouri are also found on circumneutral to calcareous soils of the prairies of Kansas, Nebraska, Oklahoma, Iowa, Illinois, and adjacent areas. An enumeration of such species includes many of the Leguminosae, Compositae, and Gramineae, such as *Liatris scariosa, Bouteloua curtipendula, Koeleria cristata, Silphium laciniatum, S. integrifolium, Brauneria pallida,*

Solidago rigida, Astragalus distortus, A. mexicanus, Petalostemum purpureum, P. candidum, Amorpha canescens, Psoralea tenuiflora var. *floribunda, P. esculenta,* etc.

The flora of the limestone glades comprises two heterogeneous elements. One group consists of the typical calciphiles. These are the species having, for the most part, deep roots which penetrate the unleached lower portions of the calcareous substratum and are, consequently, influenced directly by the chemical nature of the rock itself. This group of species is characteristic of the calcareous barrens in Missouri and the prairies in other states. The second group is not at all typical of the limestone barrens and knobs; its component species are those which possess, for the most part, shallow root systems that do not penetrate the deeper portions of the substratum but merely occur within the superficial leached areas of the glade. Such root systems do not penetrate the chemically active parts of the substratum, and are therefore not influenced by alkalinity. This second group of species, then, really comprises true oxylophytes which are characteristically found on the acidic chert, sandstone, or igneous barrens in Missouri, but which also occur on the sterile, leached-out, superficial portions of the calcareous substratum. Such, for example, are *Talinum calycinum* and *Crotonopsis elliptica.* The same sort of situation has been recorded in a number of other areas. For example, in the account of his botanical expedition in Newfoundland, Dr. Fernald,[5] writing of the Blomidon talus-slopes, states, "The freshly broken talus was slightly calcareous and had some of the common calciphiles, but the weathered rock from which the soluble lime had leached was carpeted in patches with the plants we are used to on our granitic mountains, and *Phyllodoce caerulea* was here seen for the first time in the entire summer, and *Stipa canadensis* was apparently new to the island."

A list of typical calciphiles in Missouri includes the following:—

Adiantum Capillus-veneris L.
Notholaena dealbata (Pursh) Kunze
Cheilanthes Feei Moore
Pellaea atropurpurea (L.) Link
Pellaea glabella Mett.
Asplenium resiliens Kunze
Asplenium cryptolepis Fernald
Camptosorus rhizophyllus (L.) Link
Cystopteris bulbifera (L.) Bernh.
Ophioglossum Engelmanni Prantl
Isoëtes Butleri Engelm.
Juniperus virginiana L.
Muhlenbergia cuspidata (Torr.) Rydb.
Spartina Michauxiana Hitchc.
Bouteloua hirsuta Lag.
Bouteloua gracilis (HBK.) Lag.
Melica mutica Walt.

[1] Fernald, M. L. A botanical expedition to Newfoundland and Southern Labrador. Contr. Gray Herb., N. S. 40 [or RHODORA **13**]: 133. July, 1911.

Carex eburnea Boott
Carex Crawei Dewey
Zygadenus chloranthus Richards.
Allium stellatum Ker.
Allium mutabile Michx.
Yucca glauca Nutt.
Agave virginica L.
Nemastylis acuta (Bart.) Herb.
Juglans nigra L.
Quercus macrocarpa Michx.
Oxybaphus albidus (Walt.) Sweet
Arenaria patula Michx.
Hepatica acutiloba DC.
Anemone cylindrica Gray
Trautvetteria carolinensis (Walt.) Vail
Clematis Fremontii Wats.
Aquilegia canadensis L.
Delphinium Treleasei Bush
Delphinium Nortonianum Mack. & Bush
Draba cuneifolia Nutt.
Lesquerella gracilis (Hook.) Wats.
Leavenworthia uniflora (Michx.) Britton
Arabis hirsuta (L.) Scop.
Arabis laevigata (Muhl.) Poir.
Descurainia intermedia (Rydb.) Daniels
Erysimum asperum DC.
Heuchera puberula Mack. & Bush
Heuchera parviflora Bartl.
Parnassia grandifolia DC.
Ribes odoratum Wendl.
Malus coronaria (L.) Mill.
Acacia angustissima (Mill.) Kuntze var. hirta (Nutt.) Robinson
Baptisia australis (L.) R. Br.
Cladrastis lutea (Michx. f.) Koch
Psoralea tenuiflora Pursh var. floribunda (Nutt.) Rydb.
Psoralea argophylla Pursh
Psoralea esculenta Pursh
Petalostemum purpureum (Vent.) Rydb.
Petalostemum candidum Michx.
Astragalus mexicanus A. DC.
Astragalus distortus T. & G.
Astragalus lotiflorus Hook.
Oxytropis plattensis Nutt.
Croton capitatus Michx.
Andrachne phyllanthoides (Nutt.) Muell. Arg.
Euphorbia zygophylloides Boiss.
Euphorbia dictyosperma Fisch. & Mey.
Cotinus americana Nutt.
Ilex decidua Walt.
Sapindus Drummondii H. & A.
Rhamnus lanceolata Pursh
Rhamnus caroliniana Walt.
Cissus incisa (Nutt.) Des Moulins
Oenothera missourensis Sims
Oenothera serrulata Nutt.
Gaura coccinea Pursh
Stenosiphon linifolius (Nutt.) Britton
Mentzelia oligosperma Nutt.
Lomatium daucifolium (Nutt.) Coult. & Rose
Eryngium yuccifolium Michx.
Polytaenia Nuttallii DC.
Zizia aurea (L.) Koch
Taenidia integerrima (L.) Drude
Bumelia lanuginosa (Michx.) Pers.
Diospyros virginiana L.
Diospyros virginiana var. platycarpa Sarg.
Gentiana puberula Michx.
Gentiana Andrewsii Griseb.
Centaurium texense (Griseb.) Fernald
Asclepiodora viridis (Walt.) Gray
Acerates viridiflora Ell.
Evolvulus argenteus Pursh
Lithospermum canescens (Michx.) Hitchc.
Heliotropium tenellum (Nutt.) Torr.
Onosmodium subsetosum Mck. & Bush
Onosmodium hispidissimum Mack.
Scutellaria Bushii Britton
Satureia glabella (Michx.) Briquet
Pentstemon Cobaea var. purpureus Pennell
Galium virgatum Nutt.
Houstonia angustifolia Michx.
Campanula rotundifolia L.
Viburnum rufidulum Raf.
Liatris scariosa Willd.
Grindelia lanceolata Nutt.
Grindelia squarrosa (Pursh) Dunal
Gutierrezia dracunculoides (DC.) Blake
Aplopappus ciliatus (Nutt.) DC.
Solidago Gattingeri Chapm.
Solidago Drummondii T. & G.
Solidago rigida L.
Aster oblongifolius Nutt.
Aster sericeus Vent.
Aster laevis L.
Aster azureus Lindl.
Aster ptarmicoides T. & G.
Silphium laciniatum L.
Silphium terebinthinaceum Jacq.
Silphium integrifolium Michx.
Berlandiera texana DC.
Parthenium integrifolium L.
Parthenium repens Eggert

Rudbeckia fulgida Ait.
Brauneria pallida (Nutt.) Britton
Brauneria paradoxa Norton
Marshallia caespitosa Nutt.
Palafoxia callos~~um~~a T. & G.
Thelesperma trifidum (Poir.) Britton
Thelesperma gracile (Torr.) Gray
Cacalia tuberosa Nutt.

Rarely do the calciphiles occur on acidic rocks. *Aquilegia canadensis, Carex eburnea, Cystopteris bulbifera, Adiantum Capillus-Veneris, Camptosorus rhizophyllus,* and other calcicolus species have been found on the highly siliceous St. Peter and La Motte sandstones, but in these cases some calcium carbonate may have been introduced extraneously, perhaps washed down from above, brought in from seepage-water, or otherwise introduced.

The foregoing discussion has called attention to some obvious general relationships existing between various species in Missouri and the underlying substratum. There is another aspect of this relationship which should be suggested, namely, the frequent association of a species at or near the margin of its range with a definite habitat. The interesting feature observed here is that a number of such species in Missouri are found on a marginal habitat at variance with that in which they occur in the other portions of their range which are near the dispersal center. This divergence between a marginal habitat and one near the center of dispersal for the species is well brought out in the following cases. The most common examples are species which in their usual and most abundant areas of distribution grow in acid swamps, wet woods and meadows, boggy ground, and the like. Species frequenting such habitats in their normal areas of distribution inhabit in Missouri regions of moist shaded cliffs or wet ledges of an acidic nature. The acid substratum usually selected by these species is sandstone. The following species exemplify this point:—1) SAXIFRAGA PENNSYLVANICA var. FORBESII.—Typical *Saxifraga pennsylvanica* of the northern and eastern states is a plant of wet woods and meadows. On coming south into Illinois, and Missouri it is replaced by the closely related *Saxifraga pennsylvanica* var. *Forbesii* which appears only on moist shaded sandstone cliffs. 2) VIOLA PALLENS—A common enough species of wet springy ground and brooksides in the northern and eastern portion of its range, it appears in Missouri at the southwestern limit of its dispersal in but one place known, that on moist La Motte sandstone cliffs.

Other examples illustrate the occurrence of species which appear in the swampy lowlands of southeastern Missouri and persist in

scattered areas north of this region on acidic substrata. *Osmunda cinnamomea* and *O. regalis* var. *spectabilis* both are species common in wet woods, meadows, or swamps in the greater portion of their range. In Missouri they are found in such habitats in the lowlands of the southeastern portion of the state; yet northward in the state the only places where they seem to thrive are crevices and pockets of moist shaded or mossy sandstone, granitic, or porphyritic trachyte cliffs, or along rocky streams of these substrata. *Polypodium polypodioides*, a species of the lowlands of the South Atlantic states, Gulf Coastal Plain, and Mississippi Embayment dispersal, is common on trees in the southeastern lowland region of Missouri: north and west of this area it protrudes frequently further on various sandstone, granites, and porphyritic trachytes, reaching its northernmost known occurrence in the state on a shaded bluff of St. Peter sandstone. *Mitchella repens*, a common plant either of dry sterile acid woods, thickets, and pastures, or acid peaty places in the northern and eastern portions of its range, and frequently in swampy localities in the Gulf Coastal Plain and Mississippi Embayment regions, extends up the Mississippi Valley as a characteristic plant of the lowlands of southeastern Missouri. Although northward in eastern Missouri it has been found locally in a number of places, these again and again are moist sandstone bluffs or banks of an acidic nature. *Hypericum petiolatum* and *Cardamine bulbosa* are additional examples of species which are common in swampy places both in southeastern Missouri and in other portions of the dispersal area, and northward in the state inhabit moist sandstones or other acidic rocks. *Lycopodium lucidulum* is an interesting example of a species which in the northern and eastern portions of its range is common in usually shaded woods. On coming southwestward into Ohio, Indiana, Illinois, Iowa, and Missouri it is found only on shaded sandstone bluffs; likewise, its variety, *Lycopodium lucidulum* var. *porophilum*, appears in similar situations.

There is yet another relationship found to exist between the occurrences of various Missouri species and the underlying rock substratum, namely, the range extensions effected by the substratum. Cases are numerous where certain types of rocks, particularly sandstones, provide in Missouri extensions of ranges for species which are rare or local, boreal or austral, or for ancient types—those with geologically ancient types of dispersal. Species of great rarity in Missouri, such as

Sullivantia renifolia, Saxifraga pennsylvanica var. *Forbesii*, and others, are known to occur only on St. Peter sandstone. Species of more northern affinities which extend southward into Missouri in the Ozark region on certain types of rocks are *Galium boreale* var. *hyssopifolium, Campanula rotundifolia, Zygadenus chloranthus* on limestone; *Goodyera pubescens, Viola pallens, Lycopodium complanatum* var. *flabelliforme* and *Dennstaedtia punctilobula* on La Motte sandstone; *Thelypteris palustris* var. *pubescens, Lycopodium lucidulum* var. *porophilum, Polypodium virginianum, Thelypteris spinulosa* and var. *intermedia*, on various sandstones and other acidic types of substrata. Of species of more southern affinities which extend northward into the Ozark region on particular rock substrata may be mentioned *Hypericum petiolatum* and *Polypodium polypodioides.* The species limited to the unglaciated southern Appalachian and Ozarkian region and therefore of particular interest as representing ancient types of dispersal are *Parnassia grandifolia, Trautvetteria carolinensis, Cheilanthes alabamensis, Ophioglossum Engelmanni, Isoëtes Butleri, Nemastylis acuta, Baptisia australis, Heliotropium tenellum, Grindelia lanceolata, Solidago Gattingeri* usually on limestone exposures in the Ozark region, and *Berberis canadensis, Asplenium Bradleyi, Houstonia patens* on sandstone exposures.

The examples brought out in the foregoing discussion illustrate a few of the interesting distributional relationships of various species with the substratum, and emphasize the fact that the type of underlying substratum is one of great importance in the distribution of these species in a region of residual soils such as that of the Ozark region of Missouri, and therefore becomes greatly significant in discussing the phytogeographical problems in the region concerned.

The last feature of great phytogeographic interest in Missouri to be discussed is the relative antiquity of the Ozarkian flora. Dr. Fernald[1] emphasizes this point in his introduction concerning some phytogeographic features of the eastern North American flora as follows: "Viewed from the standpoint of availability for occupation by flowering plants, the oldest large section of the region is the southern half of the Appalachian Upland, extending from central New York to northern Georgia and northern Alabama, and west of the Mississippi represented by the Ozark Plateau. Never, since it was first occupied by angiosperms, has the Appalachian Upland of the

[1] Fernald, M. L. Specific segregations and identities in some floras of eastern North America and the Old World. Rhodora 33: 25–27. 1931.

United States been invaded by seas; and, except for its northern extension, it lies wholly south of the limits of the Pleistocene glaciation. During the Cretaceous, while this southern half of the Appalachian region was covered by land-vegetation, the lower marginal country, east, south and far to the west and northwest, was submerged under the Cretaceous seas. In the Tertiary, likewise, much of the low-lying Coastal Plain was again covered by shallow seas; and, furthermore, the outer margin of the Coastal Plain is often of very modern or Quaternary origin." Map I of his article illustrates the ancient southern Appalachian-Ozarkian portion of eastern North America as one exposed since the close of the Paleozoic and available for plant occupation in eastern North America since the close of this era.

The Ozark Plateau of Missouri and Arkansas, with minor extensions into southern Illinois, southeastern Kansas, and adjacent eastern Oklahoma, has, like the southern half of the Appalachian Upland, been exposed as a land area since the close of the Paleozoic era. Like this Appalachian area, the Ozark region was uplifted at the close of the Cretaceous period, but during early Tertiary became peneplained following a long period of erosion. Over much of the Tertiary period the Ozark region was a plain of low relief covered by a luxuriant forest flora, and similar again to the peneplained southern Appalachian area this Ozark region of low relief was in Tertiary only slightly above sea-level, while the region to the south, east, and west was covered by shallow seas. At this time the great northern extension of the Gulf, known as the Mississippi Embayment, lay south and east of the Ozark area. The Mississippi Embayment became obliterated, however, towards the close of the Tertiary when another and final uplift elevated the Ozark region, which destroyed or pushed south the lowland forest that had previously occupied it. Some of this forest persists today in the lowland region of southeastern Missouri.[1] The same uplift near or towards the close of the Tertiary which hastened the extinction or migration south of much of the mesophytic flora which had covered the peneplained Ozark area, ushered in conditions making for a xerophytic or semi-xerophytic environment.

These significant geological data have a very important bearing upon the explanation of the restricted and limited ranges of a number of species in eastern North America. Both the southern Appalachian

[1] Palmer, E. J. The forest flora of the Ozark region. Jour. Arn. Arb. **2**: 229–232. 1921.

Upland and the Ozark Plateau have had somewhat similar geological history. Since the close of the Paleozoic era, each has remained an area of land standing above sea-level; each has experienced its uplifts and peneplanations, these sometimes occurring at the same geological epoch; each has witnessed its changes in flora, mesophytic types being succeeded by xerophytic ones, and vice-versa. Following the close of the Paleozoic, at times (during Mesozoic and Tertiary) when adjacent areas to the south, east, and west were flooded or submerged by continental seas, and again in the Pleistocene when areas to the north were being glaciated, the southern Appalachian-Ozarkian areas enjoyed a continuous land history. As such, both areas were able to harbour many species at times when adjacent areas were not available. Some of this flora may have had a broad dispersal from the Appalachians west to the Ozark area, but later became restricted to the southern Appalachians and the Ozark area when the flooding in adjacent areas led to exterminations. Cretaceous and Tertiary submergence of some adjacent regions, and Pleistocene glaciation of others necessarily limited the areas of distribution, and the species common to the southern Appalachian-Ozark region either have persisted there as relics or remants of an older dispersal or were forced to migrate to these land areas from other regions, or both. It appears probable that the species restricted to the southern Appalachian-Ozarkian territory, in all probability representing relics, originated in Mesozoic time, perhaps at the close of the Cretaceous period, following the uplift over the Appalachian Upland Ozark Plateau. Certainly, the species common to these two areas must have been occupying them before the Tertiary intrusion of the Mississippi Embayment, which all but broke up the territory of dispersal which formerly bridged the gap between the southern Appalachians and the Ozark Plateau. At present, only a narrow strip of the old land mass of the Ozark area remains in southern Illinois as a bridge over this otherwise enormous gap caused by the embayment.

It would appear, then, that in the southern Appalachian-Ozarkian region is to be found a center of dispersal of ancient types of species, which are as old as any in eastern North America. An investigation of the flora of this ancient area shows that there have been at least three definite centers of origin and dispersal of these old types—of relic groups of species originating or persisting on this old land mass. These centers comprise: (1) species common to both the southern

Appalachians and the Ozark Plateau and restricted thereto or also represented south and west of these two areas from which they have probably spread; (2) species restricted to the southern Appalachian area—old types which have originated in this area and are still persisting therein; and (3) species restricted to the Ozark Plateau and region southwest and west of it. Since only the first and third of these areas include Missouri species, discussion will be limited to these regions.

The list of species common to both the southern Appalachian Upland and the Ozark Plateau area include the following. It should be noted too that some of the species listed here occur somewhat south, north or west of the main area, since the original dispersal from the distributional center.

Cheilanthes alabamensis (Buckley) Kunze
Asplenium Bradleyi D. C. Eaton
Asplenium pinnatifidum Nutt.
Ophioglossum Engelmanni Prantl
Isoëtes Butleri Engelm.
Paspalum circulare Nash
Panicum xalapense HBK.
Panicum polyanthes Schultes
Aristida Curtissii (Gray) Nash
Aristida ramosissima Engelm.
Sporobolus canovirens Nash
Cyperus refractus Engelm.
Cyperus ovularis (Michx.) Torr.
Carex mesochorea Mack.
Juncus diffusissimus Buckley
Luzula campestris (L.) DC. var. bulbosa A. Wood
Stenanthium robustum S. Wats.
Trillium viride Beck
Agave virginica L.
Iris cristata Ait.
Nemastylis acuta (Bart.) Herb.
Habenaria peramoena Gray
Salix longipes Shuttlw. var. Wardii (Bebb) Schneider
Ulmus alata Michx.
Celtis pumila Pursh var. georgiana (Small) Sarg.
Trautvetteria carolinensis (Walt.) Vail
Magnolia acuminata L.
Berberis canadensis Mill.
Draba brachycarpa Nutt.
Leavenworthia uniflora (Michx.) Britton
Arabis virginica (L.) Trel.
Cardamine rotundifolia Michx.
Sedum pulchellum Michx.
Sedum Nevii Gray
Heuchera parviflora Bartl.
Heuchera puberula Mack. & Bush
Parnassia grandifolia DC.
Aruncus sylvester Kostel.
Gillenia stipulata (Muhl.) Trel.
Agrimonia rostellata Wallr.
Potentilla canadensis L. var. villosissima Fernald
Baptisia australis (L.) R. Br.
Cladrastis lutea (Michx. f.) Koch
Psoralea Onobrychis Nutt.
Psoralea pedunculata (Mill.) Vail.
Robinia Pseudo-Acacia L.
Desmodium ochroleucum M. A. Curtis
Lespedeza simulata Mack. & Bush
Cotinus americana Nutt.
Rhamnus caroliniana Walt. var. mollis Fernald
Vitis rupestris Scheele
Tilia heterophylla Vent. var. Michauxii (Nutt.) Sarg.
Viola emarginata (Nutt.) Le Conte
Passiflora lutea L.
Eulophus americanus Nutt.
Ligusticum canadense (L.) Britton
Vaccinium arboreum Marsh.
Vaccinium neglectum (Small) Fernald
Vaccinium melanocarpum Mohr
Vincetoxicum carolinense (Jacq.) Britton
Vincetoxicum Baldwinianum (Sweet) Britton
Phacelia dubia (L.) Small
Phacelia bipinnatifida Michx.
Heliotropium tenellum (Nutt.) Torr.
Monarda Bradburiana Beck

Satureia glabella (Michx.) Briquet
Pycnanthemum albescens T. & G.
Cunila origanoides (L.) Britton
Galium virgatum Nutt.
Houstonia minima Beck
Houstonia purpurea L.
Houstonia angustifolia Michx.
Houstonia patens Ell.
Lonicera flava Sims
Viburnum rufidulum Raf.
Triosteum angustifolium L.
Lobelia leptostachys A. DC.
Eupatorium sessilifolium L.
Grindelia lanceolata Nutt.
Solidago petiolaris Ait.
Solidago Gattingeri Chapm.
Silphium Asteriscus L.
Rudbeckia fulgida Ait.
Verbesina virginica L.
Coreopsis grandiflora Hogg.
Coreopsis pubescens Ell.
Cirsium virginianum (L.) Michx.

A study of the habitats of the various species in this first category shows that over half of this flora (60 percent) grows in a xerophytic environment—barrens, dry bluffs, dry rocky hillsides, prairies, and similar exposed and semi-arid situations. The herbaceous types comprise about 80 percent of the species represented.

The other great developmental center of relatively ancient types is the Ozark Plateau and the adjacent area to the west and southwest. In some instances species originating in this area are represented slightly to the east or southeast of the main area, but have spread mostly westward and southwestward; some of this class are found as far south as the Mexican plateau or as far west as Arizona. The following list comprises species restricted to the Ozark area and the region west and southwest (some of these are known only from the Ozark region):—

Notholaena dealbata (Pursh) Kunze
Panicum obtusum HBK.
Panicum malacophyllum Nash
Sporobolus asper (Michx.) Kunth var. pilosus (Vasey) Hitchc.
Sporobolus Drummondii (Trin.) Vasey
Carex austrina (Small) Mack.
Wolffia papulifera C. H. Thompson
Yucca arkansana Trelease
Sisyrinchium flaviflorum Bicknell
Quercus velutina Lam. var. missouriensis Sarg.
Castanea ozarkensis Ashe
Celtis laevigata var. texana Sarg.
Geocarpon minimum Mack.
Arenaria stricta Michx. var. texana Robinson
Talinum calycinum Engelm.
Nymphaea ozarkana Miller & Standley
Ranunculus Harveyi (Gray) Britton
Clematis versicolor Small
Clematis Fremontii Wats.
Delphinium Treleasei Bush
Delphinium Nortonianum Mack. & Bush
Corydalis crystallina Engelm.
Lesquerella gracilis (Hook.) Wats.
Lesquerella angustifolia (Nutt.) Wats.
Selenia aurea Nutt.
Sedum Nuttallianum Raf.
Saxifraga texana Buckley
Hamamelis vernalis Sarg.
Crataegus coccinioides Ashe
Crataegus lanuginosa Sarg.
Prunus hortulana Bailey
Rynchosia latifolia Nutt.
Acacia angustissima (Mill.) Ktze. var. hirta (Nutt.) Robinson
Andrachne phyllanthoides (Nutt.) Muell. Arg.
Euphorbia zygophylloides Boiss.
Sapindus Drummondii Hook. & Arn.
Aesculus glabra Willd. var. leucodermis Sarg.
Cissus incisa (Nutt.) Des Moulins
Callirhoë digitata Nutt.
Callirhoë Bushii Fernald
Viola Lovelliana Brain.

Oenothera missouriensis Sims
Opuntia macrorhiza Engelm.
Cynosciadium pinnatum DC.
Lomatium daucifolium (Nutt.) Coult. & Rose
Chaerophyllum texanum Coult. & Rose
Sabbatia campestris Nutt.
Centaurium texense (Griseb.) Fernald
Centaurium calycosum (Buckl.) Fernald
Onosmodium subsetosum Mack. & Bush
Scutellaria Bushii Britton
Physalis missouriensis Mack. & Bush
Amsonia illustris Woodson
Collinsia violacea Nutt.
Pentstemon Cobaea Nutt. var. purpureus Pennell
Pentstemon tubiflorus Nutt.
Pentstemon arkansanus Pennell
Aureolaria pectinata var. ozarkensis Pennell
Aureolaria calycosa (Mack. & Bush) Pennell
Ruellia pedunculata Torr.
Galium arkansanum Gray
Valerianella stenocarpa (Engelm.) Krok
Valerianella longiflora (T. & G.) Walp.
Vernonia crinita Raf.
Gutierrezia dracunculoides (DC.) Blake
Solidago radula Nutt.
Solidago Drummondii T. & G.
Solidago Lindheimeriana Scheele
Chaetopappa asteroides DC.
Boltonia latisquama Gray
Aster anomalus Engelm.
Erigeron tenuis T. & G.
Berlandiera texana DC.
Parthenium repens Eggert
Brauneria paradoxa Norton
Polypteris callosa (Nutt.) Gray
Gaillardia lutea Greene
Artemisia mexicana Willd.
Centaurea americana Nutt.
Krigia occidentalis Nutt.
Marshallia caespitosa Nutt.

An examination of this list also reveals results similar to those of the preceding, but showing more striking differences. Here about seven-eighths of the species comprising this flora grow under a xerophytic type of environment. Moreover, the herbaceous component amounts to 85 percent of the whole.

From an examination of the preceding lists it is evident that herbs comprise by far the majority of the species limited to the southern Appalachian-Ozarkian area of dispersal as well as to the Ozarkian Plateau and adjacent region. The herbaceous species which comprise the majority of the flora peculiar to the Ozark Plateau region represent at present the characteristic and dominant xerophytic flora of that region. These types seem either to have originated in the Ozark Plateau or to have spread into it on the dry uplands and barrens as a response to the xerophytic conditions occasioned by the last uplift of this region, which probably occurred either in late Tertiary or slightly later.[1], [2] Since the Cretaceous sea-bottoms underlying the Great Plains region were uplifted in early and again in late Tertiary times more or less coincident with the last Ozark diastrophism, it is likely that favorable opportunities were brought about for an incursion of the prairie flora into the Ozarks, during Tertiary times and

[1] Keyes, C. R. Age of Ozark Uplift. Mo. Geol. Surv. Ann. Rept. 7: 351–352. 1895.

[2] Keyes, C. R. Myth of the Ozark Isle. Science N. S. 7: 588–589. 1898.

vice-versa, resulting in the intermingling of the prairie and glade flora that we at present encounter. It is probable that most, if not all, of the species restricted to the southern Appalachian-Ozarkian area were in the Ozark region long before the other species of the prairies and glades which originated in the Ozark Plateau itself or spread into it from adjacent regions to the west or southwest. As has already been stated, the flora peculiar to the Ozark Plateau or to it and adjacent region west and southwest either originated in the Ozark region or spread into it when the last Tertiary uplift through that region resulted in elevated rocky glades and prairies in a drier and more semi-arid environment which favored the occupation by mostly xerophytic types of plants. Long before this uplift, however, the southern Appalachian-Ozarkian floristic element must have been dispersed before the northern intrusion of the Mississippi Embayment had all but severed its common connection. We have already seen that the southern Appalachian-Ozarkian flora probably originated sometime in the Mesozoic, perhaps following an uplift over these areas towards the close of the Cretaceous period. This latter flora, therefore, is probably the most ancient to be found in the Ozark region today. Thus, it may be concluded on the basis of the foregoing discussion that two geologically diverse floras occur in the Ozark region, (1) an ancient relic flora common to the southern Appalachians and Ozark region, and dating back in all probability to the uplift that occurred at the close of the Cretaceous, and (2) a younger flora, characteristic of the uplands and barrens of the Ozarks, a flora which probably originated in Tertiary times when this region was re-elevated in late Tertiary.

Missouri Botanical Garden, St. Louis, Missouri.

DOUBLE FLOWERS IN THE WILD SWAMP BLUEBERRY, VACCINIUM CORYMBOSUM

H. F. Bergman

(Plate 289)

Abnormal flowers in any species of *Vaccinium* are almost unknown. The only cases reported by Penzig (3) are adesmie of the corolla in *V. dialypetalum* J. J. Sm., and tetramery or occasional trimery in *V. uliginosum* L., which are minor abnormalities. Weatherby (5) has

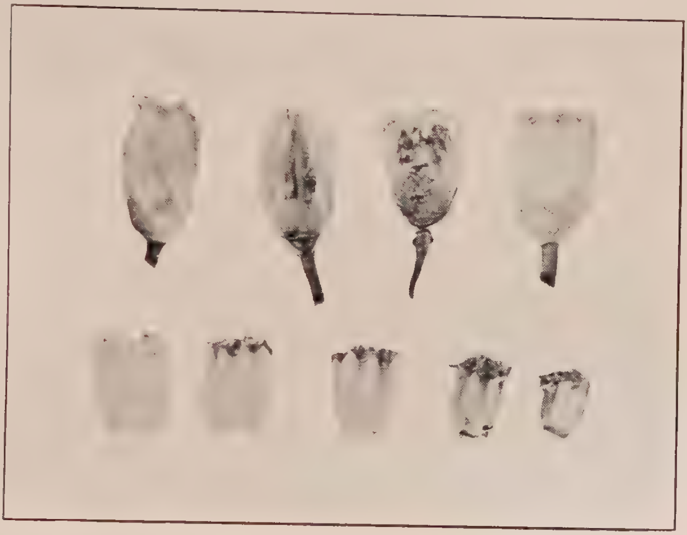
reported dialysis of the corolla in *V. pennsylvanicum* Lam. In the summer of 1926 a single plant of *Vaccinium corymbosum* L., bearing double flowers, was found growing wild in New Jersey but too late in the season to secure good specimens. No further attempt was made to obtain flowers until 1930 when specimens were collected,[1] photographed, and an examination of the flowers made. The area in which the plant grew was later burned over, so that the plant may have been destroyed unless it grows again from the roots, which cannot at present be determined.

The flowers did not appear to be different from those of any other plant of this species unless seen at close range. The calyx and corolla were of the normal form. Stamens of the normal form were lacking but in their place was a series of corolloid whorls, each enclosing successively another (fig. 1). The size of the whorls diminished inwardly until in the center of the flower only small scale-like structures were found (fig. 2). Each segment of the transformed stamens forming the corolloid whorls was tipped by an imperfectly developed brown anther. Some of the anthers contained a very limited amount of highly defective, much deformed, pollen. No vestige of a pistil was observed in any of the flowers examined.

A similar stamen condition is reported by Wilson (6) in double flowers of *Epigaea*. Double flowers due to petalody and pleiomery of the stamens have been reported by W. W. Bailey (1) in *Epigaea repens*, by Masters (2) in *Erica hiemalis*, and by Rehder (4) in *Rhododendron albiflorum*. The double flowers of *Epigaea repens* described by Bailey seem to be very similar in structure to those of the blueberry here described except that Bailey found an apparently normal pistil in the flowers of *Epigaea* which was completely lacking in the specimens here described. In the double flowers described by Masters (2) the stamens and pistil were absent but in place of the latter a short shoot covered with scale-leaves was found. No statement was made by Masters as to the presence of anthers on the supernumerary corollas. With these exceptions the condition described by him in the flowers of *Erica hiemalis* corresponds very closely to that found in the blueberry flowers.

Division of Fruit and Vegetable Crops and Diseases,
Bureau of Plant Industry,
U. S. Dept. of Agriculture, Amherst, Mass.

[1] Grateful acknowledgement is made to Mr. R. B. Wilcox, Pemberton, N. J., for sending material for examination.



Vaccinium corymbosum, × 2.

Fig. 1 (above). The two specimens at the left in the upper row show a normal blossom as seen externally and in longitudinal section; the specimens at the right the corresponding view of a double flower. In the bottom row, at the extreme left, is the corolla of a double flower; successive whorls of corolloid stamens are shown in order to the right.

Fig. 2 (below). Upper row left to right, the pistil of a normal flower; pistil of an abnormal flower showing absence of style and ovary; corolloid stamens; the same split lengthwise and opened out. The bottom row shows different views of normal stamens.

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6. Wilson, Kate E. Double flowers of the Epigaea repens. Bot. Gaz. 15: 19. 1890.

SMALL'S MANUAL OF THE SOUTHEASTERN FLORA.[1]—To botanists of eastern North America, Dr. Small's work needs no introduction. They have long respected it and found it indispensable; they will have a cordial welcome for this latest addition to it. A reviewer's function is sufficiently performed if he make some comparison of this Manual with the Flora which preceded it.

Certain changes are at once obvious. Although the number of pages is actually larger, thin paper has reduced the thickness of the volume by nearly one-third. The geographic area covered has been made smaller and more homogeneous by leaving out the states west of the Mississippi River. Each genus and in the case of *Carex* each section now has one clear and useful little illustration of floral parts and fruit. The longer keys have been recast into the two-story form generally used in the North American Flora—a primary key to groups of species, which are given series-names, and secondary keys to the individual species of each group. This arrangement has the advantage of bringing the main key-headings close together and, while retaining the visual clarity of the indented key, avoiding the successive steppings-back which sometimes reduce the letter-press to a narrow band at the right of the page. Many descriptions have also been skilfully and profitably rewritten,[2] and, of course, much new matter has been added from the accumulations of twenty years.

On the other hand, users of the Flora will find the general method and taxonomic point of view of the Manual wholly familiar. It affords added evidence of Dr. Small's ready hospitality to the work of others. Beside many revisions incorporated into his text, acknowledgment is made of direct aid from eighteen colleagues. Mr. Mackenzie's excellent and finely illustrated revision of *Carex* deserves especial mention here.

Familiar, too, will be the continued use of the American Code. That certain practices not now sanctioned should be kept up after the accord happily reached at the Cambridge Congress is regrettable. Apology is made for some coadjutors who are now following the International Rules

[1] Small, John Kunkel. Manual of the Southeastern Flora, being Descriptions of the Seed Plants growing naturally in Florida, Alabama, Mississippi, eastern Lousiana, Tennessee, North Carolina, South Carolina and Georgia. New York. Published by the Author. 1933. pp. xxii, 1554. Ill.

[2] In preparing our notes on the spring flora of eastern South Carolina, Mr. Griscom and I, then using the 1913 edition of the Flora, had occasion to point out some deficiences in its statements. These passages had to be deleted when the Manual appeared; it had anticipated and adequately met our criticisms.

on the ground that their contributions were already in type in 1930. The same might be said for Dr. Small's own work; the difficulties of changing nomenclatural habits in a work well under way are considerable. And in his case it could be added that this is his personal publication in which individual views can more fittingly be maintained than under the imprint of an institution. Nevertheless, it is a pity. Nomenclature is, after all, only a convention; convictions are out of place in it. The one thing worth striving for is unanimity—with common sense if possible, but, anyway, unanimity.

There is little occasion for a die-hard attitude among former partisans of the American Code. They need labor under no deep sense of defeat. If they have failed to persuade the botanical world to abandon custom altogether for a rigid priority, they have yet written into the now accepted rules much of that for which they have contended. The rules of 1930 are more like the American Code than like those under which the sixth edition of Gray's Manual and the earlier of the great floras emanating from Kew were prepared. The step to them ought not to be difficult.

The nomenclatural feature of the book hardest to regard with complacency is the unquestioning acceptance of changes in typification made under the American Code purely to satisfy its academic theory of selection of types and resulting in confusing shifts in the application of familiar names. An extreme example is *Solidago rigida*. This has been abundantly discussed by Mr. Mackenzie and me;[1] it is enough to recall that this name has been applied, ever since 1753 and with practical, if not complete, unanimity, to a certain well-marked species, represented by specimens in the herbaria of Linnaeus and of Clifford. It is now moved and made to displace another well-known and well-fixed name, simply because an individual interpretation of a dubious plate cited (unluckily) by Linnaeus is preferred to the specimens mentioned as a basis for typification. To one who holds the view of nomenclature outlined above, such abandonment of achieved definiteness for incurable indefiniteness is the *reductio ad absurdum* of the type method.

The choice of one name appears to follow no rule. *Lyonia* Ell. (1818), taken up for the more familiar *Seutera* of the *Asclepiadaceae*, is antedated by *Lyonia* Raf. Med. Repos., Hex. 2, v. 352 (1808). The latter is wholly illegitimate, being a direct substitute for *Polygonella* Michx., but it is correctly published and would seem to prevent any later use of the name, except by conservation.

The dividing up of genera proceeds, logically, a few steps farther than before. *Clintonia* and *Streptopus*, for instance, at first sight not particularly promising subjects for segregation, become two genera each; *Polygala* appears as five; *Gaylussacia* is dissolved into three; and the disintegration of *Vaccinium* is completed by the setting up of *Herpothamnus* for *V. crassifolium*. In his preface, Dr. Small disclaims any title to the appellation of "splitter"; he has, he says, endeavored "to make the genera, as far as possible, correspond in rank to the great majority of groups of species now recognized as genera by most present-day botanists." Granting that there is a tendency toward microgenera, it is still possible to doubt if a general poll of present-day botanists would really show a majority in favor of quite such finely-drawn divisions as many of Dr. Small's.

[1] Rhodora xxviii. 29–31; 138–145; xxix. 26–32.

Some newly-launched genera run at once on nomenclatural rocks. *Buxella* and *Lasiococcus* Small, of the *Vacciniaceae* are antedated respectively by *Buxella* van Tieghem (*Buxaceae*), Ann. Sci. Nat. ser. 8, v. 326 (1897) and *Lasiococca* Hook. f. (*Euphorbiaceae*) Icon. Pl. t. 1587 (1887); and *Rotantha* of the *Campanulaceae* is a later homonym of *Rotantha* Baker (*Lythraceae*), Journ. Linn. Soc. xxv. 317 (1890).

If one dislikes subgenera, he will naturally have an equal dislike for varieties; only occasionally, as in the case of the purple-flowered var. *Elliottii* of *Cirsium horridulum*, does Dr. Small give one incidental mention. As before, he gives full specific rank to any form which he finds deserving of recognition at all. One result is that, with additional material, even Prof. Burgess's far from conservative 95[1] asters are increased to 106; and *Iris*, with *I. verna* and *I. cristata* removed to another genus, is expanded from 8 to 96 species. It should be said at once, however, that this latter is no haphazard description of slightly different herbarium specimens. The remarkable iris-beds of Louisiana, from which most of the novelties came, have had prolonged study, plants have been grown at New York and seedlings watched to maturity. The interpretation, as Dr. Small rather attractively calls it, rests, then, on well-fortified conviction and treats of an unusual natural phenomenon. Even so, as one contemplates Bicknell's 36[1] *Sisyrinchia* of 1913 reduced to 12 by Mr. Alexander and Beadle's 180[1] *Crataegi* shrunk to 33 under Mr. Tidestrom's hand, one is perhaps to be pardoned for wondering what the genus *Iris* will be like in the edition of 1953.

The taxonomic outline, then, of the Manual shows, in general, close resemblance to that of the Flora, but it is to a much greater extent and to the notable and praiseworthy broadening and improvement of the work, filled in with correlative information. Much more attention is paid to phytogeography. Like other eastern botanists, Dr. Small has found that Merriam's life zones do not work well here as units of plant distribution. He takes instead Fenneman's physiographic divisions and obtains thereby clear and reasonable geographic provinces. With Dr. Wherry's aid, the divisions in which each species is found are given, so far as present information permits.[2] There are especially detailed and careful statements of habitat; soil-preference is indicated when possible. And the interest of the work is not a little enhanced by the further addition of miscellaneous notes on local uses of plants, vernacular names and the like and of critical observations drawn from Dr. Small's long and mature experience.

There may well be differences of opinion as to the limits of genera and the worth of species. No doubt there should be until our knowledge is perfect. There can be none as to the value of a work like this, the fruit of many years' labor in a field which the author has made peculiarly his own. The Manual will be for long a standard; it will always remain one of the notable American floras.—C. A. Weatherby.

[1] These figures are arrived at by deducting from the total in the Flora of 1913 those species which occur only west of the Mississippi.

[2] In a few cases, a still more detailed statement of range would have been desirable. *Leptochloa filiformis* and *Aristida oligantha* are credited to Massachusetts and *Hordeum pusillum* to Maine, as if they were native there. They are actually known in these states only as waifs in mill-waste at one or two stations separated by considerable distances from the really natural range of the species.

A Conical Sugar Maple (Text Fig.).—In 1917, while spending the summer with my family at North Woodstock, New Hampshire, I was much surprised, as others have been, by a remarkable tree of *Acer saccharum* Marsh., growing in a rocky pasture on the land of George

C. Cook, Esq. I first visited the tree because, from a distance, I took it to be a White Spruce, *Picea glauca,* considerably south of its known range in New Hampshire. Upon getting near I found that the broad cone (30 feet or 9.15 m. high) was a Sugar Maple. Mr. Cook informed me that the tree was then, in 1917, approximately 70 years old, that it has never been trimmed nor browsed, that it does not flower and

that in autumn it becomes a russet-brown, without the brilliant yellow tone of ordinary sugar maples. The branches are strongly ascending and the foliage is all borne at the tips of the branchlets, so that from without the tree appears densely leafy, but close to, when viewed from below, it has an open ladder-like appearance. The tree is one of the curiosities of the region,[1] sometimes reproduced on picture post-cards, one of which Mr. Cook supplied me in 1917. In attempting to clear off accumulations of specimens from past seasons I find the material and the photograph and, since the tree seems not to have a definite name, I am calling it

Acer saccharum Marsh., forma **conicum**, f. nov. (fig.). Arbor conicus ramis adscendentibus apice foliosis.—New Hampshire: open, rocky pasture, North Woodstock, specimens collected September 18, 1917, *M. L. Fernald*, type in Gray Herbarium.—M. L. Fernald.

A SUPPOSED HYBRID BETWEEN THE OAK SPECIES Q. RUBRA AND ILICIFOLIA

H. A. Allard

The Red Oak, *Quercus rubra* L., and the Bear Oak, *Q. ilicifolia* Wang., are very common elements in the flora of the area embraced by the Shenandoah National Park in Virginia. Both species produce a dominant cover in some sections of this area, and are found on the highest peaks of the Skyline drive, namely Marys Rock, 3514 ft., Stony Man, 4010 ft., and Hawksbill, 4049 ft. On the high peaks, at least, the former sometimes appears to pass into the variety *ambigua* (Michx.) Fernald, with much deeper and more turbinate cups. Specimens of this type may be found on the Hawksbill near its highest point. In the same vicinity and elsewhere individuals occur producing the flat saucer-shaped cup of typical *rubra*. Both the Red Oak and the dwarf Bear Oak grow in close proximity in many localities, even on the highest peaks.

On September 23, 1933 the writer found on Little Stony Man several dwarf specimens of an oak bearing all the ear-marks of a hybrid involving *rubra* and *ilicifolia* parentage. The shrubs had the low scraggy growth of *ilicifolia* and were fruiting heavily. The

[1] On May 25, 1934, passing through North Woodstock with a class of students, we noted the roadside sign "The Mystery Tree" pointing to the conspicuous tree which looked vigorous and as perfect in form as in 1917.

leaves, of the general shape of *ilicifolia* but larger and with more bristle points on the lobes, are nearly smooth and green beneath as in *rubra*, not having the close persistent white-downy pubescence of *ilicifolia*. The twigs, likewise, are smooth and reddish in color as in the case of *rubra*. The fruit is somewhat larger than that of *ilicifolia*, with the shallow flat cup of *rubra*. The acorn is more of the shape of *rubra*, but with the light and dark longitudinal stripes or bands often present on typical *ilicifolia* acorns. Large quantities of acorns were secured from these dwarf individuals, and planted to observe the genetic behavior of this interesting form. Specimens have been placed in the United States National Herbarium.

A number of supposed hybrids between the Bear Oak and other species of the Black Oak group have been recognized, involving crosses with *velutina* (× *Q. Rehderi* Trel.); with *phellos* (× *Q. Giffordi* Trel); with *marilandica* (× *Q. Brittonii* Davis); with *coccinea* (× *Q. Robbinsii* Trel.); with *rubra* var. *ambigua* (× *Q. Lowellii* Sarg.), the latter having been found at Seabury, York Co., Maine.

Bureau of Plant Industry,
Washington, D. C.

Wolffia in Massachusetts.—Last August, while collecting specimens of *Zizania* in a small marsh near Northampton, I noticed a green coating on the surface of the water which was apparently due to some member of the *Lemnaceae*. This proved to be almost a pure colony of *Wolffia columbiana*. The marsh is located in the Northampton-Easthampton meadows (Mt. Tom Station) along a small tributary of the Connecticut river oxbow; although the plant may be present in the oxbow itself, I have not seen it there. *Wolffia* has been reported from several places in Connecticut and from Lake Champlain, but this seems to be the first record of the genus in Massachusetts. It may have been very easily overlooked in other localities.—Wayne E. Manning, Smith College.

Volume 36, no. 425, including pages 133–196 and plates 284 and 285, was issued 12 May, 1934.

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